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GLACIERS AND GLACIATION OF YAKUTAT BAY, ALASKA.*

BY

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LOCATION.—The Yakutat Bay Inlet penetrates the St. Elias chain just south of Mt. St. Elias, forming the only considerable indentation on the long stretch of regular coast-line between Cross Sound and Controller Bay. The inlet is in the form of a bent arm, the broad part where it leaves the ocean being called Yakutat Bay, the narrow portion near the elbow Disenchantment Bay; the remainder Russell Fiord, from which there is one large arm, Nunatak Fiord. For the greater part of its length the inlet is mountain-walled; but part of the shores of outer Yakutat Bay and the head of Russell Fiord are a low moraine and outwash gravel plain, formed during a former stage of greater glaciation. This plain is called the Yakutat foreland.

EXISTING GLACIERS.

GENERAL DESCRIPTION.—Four large glaciers descend from the mountains surrounding the inlet, three of them—the Turner, Hubbard, and Nunatak—entering the sea. The fourth, the Hidden Glacier, descends nearly to sea-level, but terminates at the head of a gravel plain built in Seal Bay by outwash gravels from the glacier. Besides these great glaciers there are two or three score more within sight of the fiord, some of them tributary to the large glaciers, others independent. Of the latter some descend nearly to the sea, others

*The observations outlined below were obtained in connection with a geological study of the Yakutat Bay region by a United States Geological Survey party, in 1905, in charge of the senior author. A grant of money from the American Geographical Society made it possible to add the junior author to the party, as special assistant in physiography. Acknowledgments are due to B. S. Butler, the other member of the party, for assistance in this work.

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occur at the heads of valleys, and still others in the mountain cirques. Many of them have moderate slope, and there is every gradation from these to glaciers which occupy valleys having such a steep slope as to render the glacier ice unstable. In fact, one of these slid out of its valley while we were in the fiord.

When Russell viewed the country north of Mt. St. Elias he found it to be "a vast snow-covered region" with hundreds of mountain peaks projecting through it—"a land of nunataks." The maps of the Canadian Boundary Commission bring this feature out clearly. The region northwest, northeast, east, and southeast of Yakutat Bay is partly drowned in ice-fields, all the valleys being ice-filled. The large glaciers are outlets of this interior ice drainage and quite different from ordinary valley glaciers, like those of Puget Peninsula* and the smaller glaciers along the bay, which are merely outlets of local ice basins. It is possible to go over ice divides from one large glacier to another, and in several instances the prospectors have made use of these glacial highways. It is an inviting and virgin field for geographical exploration.

All the larger glaciers were studied as fully as time permitted, and a number of the smaller ones were made the subject of some investigation. They reveal many interesting features, some of which will be described under the succeeding headings. The four large glaciers were studied and described by Prof. Russell, and later by Dr. Gilbert,† to whose photographs, descriptions, and interpretations we owe much.

THE HUBBARD GLACIER.—This great glacier, one of the largest in Alaska, descends from an unknown source far back in the St. Elias range, and advances boldly into the bend of the fiord, its icy cape forming one of the points dividing Disenchantment Bay from Russell Fiord. For about four miles it presents a jagged ice-cliff rising from 200 to 300 feet above the fiord and almost constantly discharging icebergs from its face. These discharges send out great ring waves, which spread to the neighbouring shores, causing a succession of breakers far down Disenchantment Bay, even beyond Haenke Island. The procession of icebergs, reinforced by a lesser supply from the Turner and Nunatak Glaciers, passes down Disenchantment Bay, and thence down the west shore of Yakutat Bay, often forming such dense bands as to seriously interfere with navigation. So much ice melts or goes ashore that little reaches the

* This name is proposed for the peninsula between Russell Fiord and Yakutat and Disenchantment Bays. Puget, one of the earliest explorers of this region, certainly desires to have his name applied to some part of it.

† Harriman Alaska Expedition, Vol. III, GLACIERS, 1904, pp. 45–70.

FIG. 1.—LOOKING SOUTHWESTWARD ALONG SOUTHEAST MARGIN OF HUBBARD GLACIER, SHOWING VALLEY BETWEEN IT AND VARIEGATED GLACIER, WITH MARGINAL LAKES ENCLOSED. SHOWS THE SWINGING OF THE HUBBARD MORAINE WESTWARD, NEAR THE ICE TERMINUS.

FIG. 2.—VARIEGATED GLACIER FROM ELEVATION OF 1,000 FEET ON GILBERT POINT. TWO GLACIERS DESCEND FROM THE MOUNTAINS AND UNITE TO FORM A MORAINE-COVERED, APPROXIMATELY STAGNANT, BULB-SHAPED PIEDMONT AREA. (SEE FIGS. 3, 4 AND 5.)

Pacific. Some of the ice is swirled by tides and currents into Russell Fiord, and this ice, added to the supply from the Nunatak Glacier, dots the surface of Russell Fiord as far as Cape Enchantment. South of this cape icebergs become rapidly less numerous, but scattered bergs were found nearly to the head of the bay.

The Hubbard Glacier is made by the union of two large arms to which numerous smaller glaciers are tributary. Both are greatly crevassed, as is the glacier below their union; and both are nearly free from moraines except at their margins. The western arm bears a medial moraine, and the lateral moraine of the north side of the eastern arm comes down to the sea nearly parallel to it. In consequence of the general absence of moraine the glacier front is, on the whole, a clean, beautiful ice-cliff except at the very margins, where it is blackened by morainic débris.

Both arms of the glacier have an abrupt descent where they emerge from their mountain valleys, thus introducing a step in the otherwise gentle slope of the ice. Apparently, if the ice were removed from this valley there would be revealed here an upward step from the main valley into each of these tributaries. Of the two glacier arms the eastern is the larger; and the direction of the ice-currents, as indicated by the medial moraines, is dominated by this arm below its union with the western tributary.

The Variegated Glacier.—Adjoining the Hubbard Glacier on the south is an extensive moraine-covered area fed by two rather small glaciers (Fig. 2). The southern arm heads in a low divide (Fig. 3), from which another glacier descends eastward towards Nunatak Fiord; the northern arm heads among the mountains, and descends in a deep, narrow, sinuous mountain valley. The two, uniting, form a bulb-like expansion which is almost completely covered with moraine, and which in large part is nearly, if not quite, stagnant. In one place this piedmont bulb coalesces with the moraine-covered margin of the Hubbard Glacier; but for much of the distance it is entirely separated from the Hubbard Glacier (Fig. 1); and it is apparently not influenced in any way by the Hubbard Glacier, or the Hubbard by it. In consequence of this it has been deemed proper to consider this ice-mass a separate glacier and not a part of the Hubbard. Because of its vari-coloured moraines it is named the Variegated Glacier. It nowhere presents an ice-cliff to the sea.

A remarkable feature of this glacier is the presence upon it of a series of roughly concentric moraines, differing from one another in colour because of the predominance of rocks of different colours

in the several moraines. One band is black because of the abundance of black hornblendic gneiss; another gray because of the presence of a large percentage of white granite boulders; a third is purple by reason of the great quantity of purple gneiss boulders; and a fourth is orange-coloured because of a bright orange rust on a gneiss which predominates in it (Figs. 3 and 4). Because of their strong colour and their marked height these moraines are prominent features even at a distance of five or six miles. They are not terminal moraines, but bands of débris on the ice surface, brought into strong relief by ablation. The highest of them rise over 100 feet above the base (Fig. 3), but all are found to have ice in them at the depth of a few feet. This ice is melting out so rapidly that there is little vegetation on the moraine because of its frequent slipping. If all the ice should melt out from beneath the moraines there would still be left a series of ridges differing prominently in colour, but of no great height.

The source of these vari-coloured moraines is evidently the cliffs enclosing the two contributing glaciers, where each of the rocks forming the moraines occurs. That the material is not basal in origin is proved by its highly angular character, which is that of lateral moraines and not of the ground moraine. Since the ice of the contributing glaciers is not now in even contact with some of the cliffs from which the rocks must have been derived, notably the black hornblendic gneiss, it is believed that these moraines were brought down during a higher stage of the ice, when the two glaciers pushed their bulb-shaped terminus out into the fiord. This moraine-covered ice is now melting away, but some ice still exists under the moraine almost down to the shores of the fiord. Under the moraine cover the ice is disappearing very slowly, and no difference is distinguishable in the photograph taken by Dr. Gilbert in 1899 from our view in 1905.

In the midst of this moraine is an extensive depression about 95 feet above sea-level and 150 feet below the level of the moraine-covered ice which separates it from the sea (Fig. 5). Into this depression pours water from each of the tributaries of the Variegated Glacier. The gravels which these streams bear are in part built into a gravel plain in the midst of the moraine; but some escapes through a gorge in the moraine-covered ice, through which the united glacial streams flow to the sea. That this outwash gravel plain is underlain by ice is proved by the existence of pits at present being formed on its floor by the slumping due to melting out of the ice-floor. This depression apparently represents an area of ice relatively clear of moraine, and consequently much more rapidly

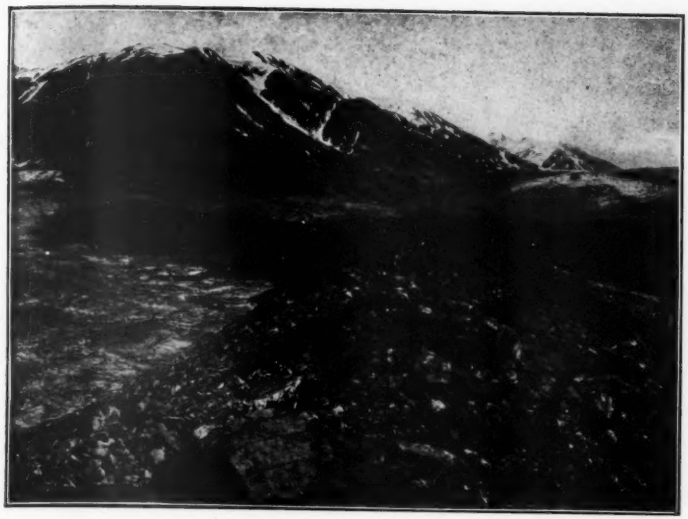

FIG. 3.—THE ORANGE GLACIER (ON THE LEFT), WITH THE INNERMOST OF THE CONCENTRIC MORAINES. THE THROUGH-GLACIER ARM OF THE VARIEGATED GLACIER SHOWS ON THE RIGHT. VIEW LOOKS NORTHEASTWARD, AT ELEVATION OF 870 FEET. CAMERA STANDS ON CREST OF MORAINE BENEATH WHICH IS ICE.

FIG. 4.—MORAINE-COVERED, BULB-SHAPED TERMINUS OF VARIEGATED GLACIER, FROM ELEVATION OF 850 FEET, LOOKING SOUTHWESTWARD. TURNER GLACIER IN BACKGROUND. THE CONCENTRIC MORAINES ON THE GLACIER, AND THE GRAVEL PLAIN BETWEEN THEM ARE BROUGHT OUT.

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lowered by ablation. On either side the moraine-covered ice rises abruptly 100 feet or more. There is represented here the rather anomalous condition of glacial streams emerging, not from the ice terminus, but two or three miles from it, flowing over and through the glacier, and building an outwash gravel plain upon it.

THE TURNER GLACIER.—This glacier, approximately a mile wide in its mountain valley, spreads out in a flat, fan-shaped ice-foot on emerging from its valley, and by this means more than doubles its width at its terminus in Disenchantment Bay. Like the two arms of the Hubbard Glacier, the Turner descends by a step from its mountain valley (Fig. 6); and this is interpreted as indicating that the Turner Glacier valley is hanging well above the level of the main valley occupied by Disenchantment Bay. The glacier is greatly crevassed, and is evidently actively advancing, since there is frequent discharge of icebergs along its sea cliff, which, by Locke level, was found to rise about 200 feet above the water. Along each margin there is a narrow band of lateral moraine, which at the front rests on the land, forming a dirt-laden toe projecting from the ice-foot. There is also a medial moraine.

THE NUNATAK GLACIER.—A few miles above the terminus two large arms unite to form this tidal glacier (Fig. 8). The southern arm heads in a broad, low divide—a characteristic feature of many glaciers of this region. Instead of being formed by the union of a series of tributaries fed from lofty cirques and snow fields, this glacier, like many others in the region, rises by moderate grade to a flat ice divide, filling a broad valley from side to side and sending glaciers down from the divide in both directions. Tributaries enter from the valleys of the enclosing mountains, but at least a part of the glacier supply comes from the accumulation on the broad, flat divide which rises well above the snow-line. The grade is so slight across the divide that several years ago the Nunatak Glacier was used as a highway by large numbers of prospectors, who crossed over this ice divide into the Alsek valley. For this condition of glaciers, extending up to broad ice divides, and continuous with similar glaciers extending in the other direction, the name *Through Glaciers* is proposed (Figs. 7 and 8).

About two miles back from its terminus the Nunatak Glacier divides into two distributaries, or tongues, the smaller ending in a land valley, the larger, about a mile wide, ending in the fiord, in an ice-cliff (Fig. 7), from which there is incessant discharge of bergs. These two tongues are separated by a rock hill rising 1,440 feet (by barometer) above the fiord. When this glacier was first seen by

Russell in 1891 its two arms completely encircled this hill, whence the name Nunatak Glacier. In 1905 the two ice-tongues did not more than half surround the nunatak.*

Just south of the terminus of the land end of the Nunatak Glacier there is a pronounced hanging valley, from which a glacier emerges, and, descending over the lip of the hanging valley, rests on a series of ledges formed by lateral sculpturing of the cliff face during a recent stage of higher ice (Fig. 9). This hanging glacier terminus, with its crevassed steps, suggested to Dr. Gilbert the very descriptive name of Cascading Glacier. On the north wall of the fiord, just below the terminus of the sea end of Nunatak Glacier, is another hanging valley occupied by a glacier; but this one does not pass beyond the edge of the hanging valley, and its terminus is covered with moraine (Figs. 14 and 15).

The Hidden Glacier.—This large glacier, about a mile wide, descends with moderate slope from a broad, flat ice divide to within a little more than two miles from the sea. Its surface is only slightly crevassed, and it is very clean and free from débris. Even the lateral moraines have but moderate development. From its front emerge two glacial streams, the larger, a rushing torrent, coming from the south side. These streams are building an outwash gravel plain in the valley (Fig. 10). This plain fills the valley bottom from the ice terminus, where its elevation is 150 feet, to the sea at the head of Seal Bay, forming a gently-sloping valley-bottom plain over which the glacial streams flow in braided courses. The upper part of this plain occupies the site of the ice terminus when photographed by Dr. Gilbert in 1899;† and, near the glacier, ice is visible beneath the gravel plain. That the ice underlies the gravel plain for at least a mile below the present terminus of the visible glacier is proved by the presence on this plain of numerous pits and kettles from a few feet to 250 feet in longer diameter (Fig. 11) and 5 to 15 feet deep. These kettles have steep, angular gravel margins, which were in process of development during our visit, being surrounded by a cracked, faulted, and fissured area, due to the withdrawal of support from beneath. Some of the kettles were dry, but many contained water, and from some clear, cold water flowed away, to form minor streams on the gravel plain.

As has been shown by Dr. Gilbert, who first described this plain, the presence of ice beneath the gravels is here giving rise to a *pitted plain*—a phenomenon with which glacial geologists are fa-

* For this hill the name Gannett Nunatak is proposed, after Henry Gannett, whose maps of the Nunatak and other glaciers show the position of the ice-fronts in 1899.

† See Harriman Alaska Expedition, Vol. III, Plate VI, opposite p. 56. Compare with Fig. 15.

FIG. 5.—OUTWASH GRAVEL PLAIN BETWEEN MORAINE-COVERED ICE RIDGES, LOWER BULB-SHAPED END OF VARIEGATED GLACIER. VIEW TOWARD SOUTHWEST, FROM MORAINE-COVERED ICE, ACROSS GRAVEL FLAT TO MORAINE-COVERED ICE NEARER THE SEA, ENCLOSING THE GRAVEL FLAT IN A SWEEPING CURVE, CONCAVE TOWARDS THE GLACIER.

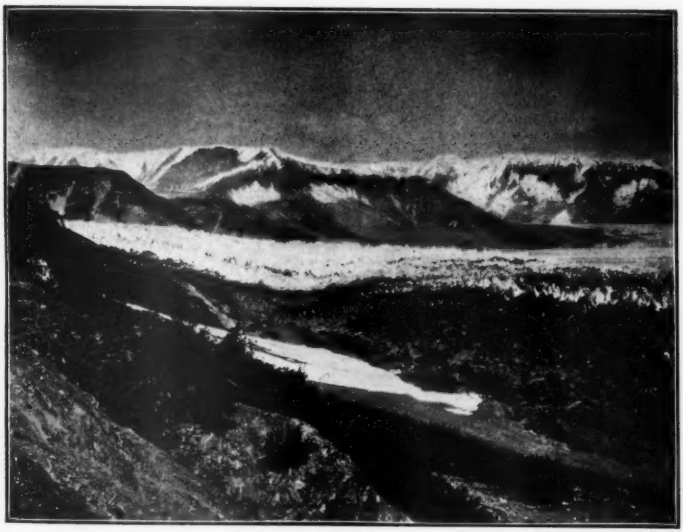

FIG. 6.—PROFILE OF LOWER END OF TURNER GLACIER FROM ELEVATION OF 525 FEET. VIEW LOOKS NORTH.

miliar among the deposits of continental glaciers. That a large mass of ice can be left in front of a receding glacier and be then protected from rapid melting by a veneer of outwash gravels has been inferred from a study of glacial phenomena; but here the process is actually visible. Among the interesting phenomena presented by this incipient pitted plain is the presence of ice directly connected with a living glacier yet not moved perceptibly by it. That the connection is complete is capable of proof by direct observation; and that the connection does not involve a marked forward thrust is proved by the undisturbed surface of the overlying gravel plain. Evidently the glacier terminus is itself nearly, if not quite, stagnant.

On the northern margin of the Hidden Glacier the ice is resting on a gravel deposit of earlier date, which it has overridden without removal (Fig. 12). This observation supplements that of Dr. Gilbert, who, in describing the same gravel deposit a half mile farther down the valley, called attention to the fact that it had been overridden. The proof of such former overriding is very clear both here and in other parts of the fiord, as will be shown under another heading. Thus the Hidden Glacier presents two interesting phenomena of opposite character—(1) the glacier is overriding earlier gravels on the north side, and (2) in the middle of its front is itself covered by gravels derived from its own melting.

Minor Glaciers.—A number of the smaller glaciers were studied; but the results of these observations will not be presented in detail here. One fact of general interest is illustrated by a large number of the smaller glaciers—namely, the great areas of morainic débris upon the lower ends. This moraine frequently covers the glacier from side to side and for a distance of from one to three miles from the terminus. Very often the moraine cover completely hides the ice, so that it is impossible to fix its exact terminus. But generally, even when the ice is not visible, its presence is indicated by the large quantity of water which emerges from the moraine as springs, and by the fissuring of the moraine, due to slumping as the ice is melted out from beneath it. Such moraine cover is usually associated with stagnant or nearly stagnant ice, and its presence is evidently an important factor in retarding the melting of the ice. On such moraines alders and willows frequently grow, sometimes forming thickets. Some of the alders are from fifteen to twenty years old, but more commonly they are less than five or six years.

This abundance of moraine is due in part to the friable nature of the weak rocks of the Yakutat Series, which are readily disrupted by frost action; but moraine-covered glaciers are also found among

the crystalline rocks. Both here and in the glaciers among the weaker rocks an important cause for abundance of moraine is the form of the enclosing valleys, which have been over-deepened, and have had their sides greatly steepened by glacial erosion during a recent period of greater ice advance. This has given to the enclosing valley walls an unstable form, which yields readily to rapid weathering, and therefore tumbles great quantities of rock fragments down upon the glaciers.

THE BLACK AND GALIANO GLACIERS.—These two glaciers, on the west side near the head of Yakutat Bay, were photographed by Prof. Russell in 1890, and a comparison of the present conditions with those of 1890 reveals some astonishing facts. The Black Glacier has scarcely changed at all, and an examination of its front, with Russell's photograph in hand, from essentially the same site as that from which it was taken, showed changes of only minor degree. It still comes out to the end of its mountain valley and terminates in an abrupt ice-cliff without expansion, and is apparently in almost the exact position it occupied during Russell's visit. That it has not recently been more than 200 or 300 yards farther out is proved by the presence at that distance of a mature forest, while at a distance of 100 yards from the ice there is an alder growth with bushes from ten to fifteen years old.

Galiano Glacier, about two miles farther southwest, on the other hand, has undergone profound change. Russell's photographs show it as emerging from its mountain valley and spreading out fan-shaped on the plain between the mountains and the sea; and it still has this condition. But both Russell's description and his photographs show that this expanded, moraine-covered terminus was in 1890 covered with dense alder growth and some trees, whereas there are now no trees on it and only a few scattered alders five or six years of age. There are, however, numerous fallen trunks, and a large number of torn stumps standing upright on the face of the moraine-covered ice-front. The vegetation of Russell's day has evidently been destroyed by an advance of the ice.

Russell's photographs of this glacier reveal an extensive alluvial fan in front of it which no longer exists. In its place occur morainic hummocks through which the fan-building stream now flows, depositing its gravels among the hummocks. Concerning these facts the evidence is clear and convincing, but it has been found difficult to place upon them a satisfactory interpretation. Proper consideration of this problem would require more space than is here available. The problem is, why should two neighbouring glaciers show such differ-

FIG. 7.—NUNATAK GLACIER (SEA END) FROM THE NORTH SIDE OF THE FIORD. SHOWS THE THROUGH-GLACIER CONDITION OF THE SOUTH ARM. GANNETT NUNATAK ON THE RIGHT.

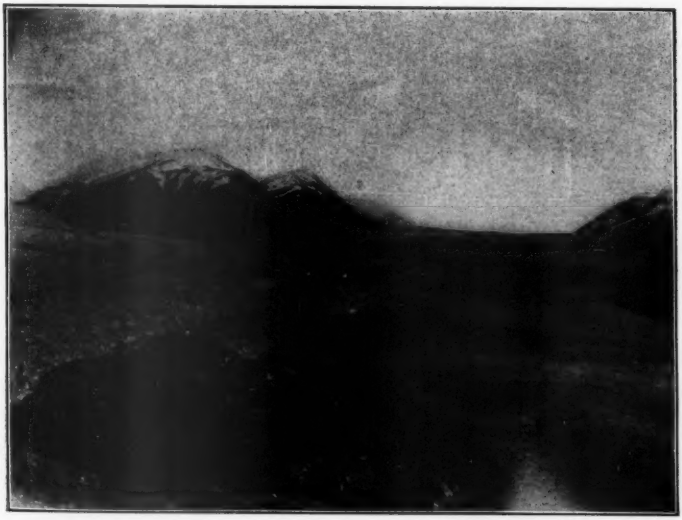

FIG. 8.—NUNATAK GLACIER FROM CREST OF GANNETT NUNATAK AT ELEVATION OF 1,400 FEET. SHOWS THROUGH-GLACIER CONDITION OF SOUTH ARM OF NUNATAK GLACIER.

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ent histories in a given time? And exactly what have been the changes on and in front of the Galiano Glacier? This problem will be discussed more fully in the final report of the expedition.

FALLEN GLACIER.—Photographs by both Russell and Gilbert, taken respectively in 1891 and 1899 from the summit of Haenke Island, show three small hanging glaciers in steep valleys on the west side of Disenchantment Bay, south of Turner Glacier. The southernmost of these glaciers was over a mile long, and its terminus about 1,000 feet above the water. On the third day of July we photographed this glacier from the fiord nearly opposite, and this proved to be the last day in its life. The next day at ten o'clock, when we were fortunately in Russell Fiord, about fifteen miles away, we were surprised by the appearance of a series of waves which rose on the shore fifteen to twenty feet vertically, and continued for nearly half an hour. Later we found that the glacier had slid bodily out of its valley and tumbled into Disenchantment Bay, leaving only a few small remnants clinging to the valley sides.

On visiting the valley later in the season the destruction performed by the glacial avalanche was found to be extensive, and the smoothed bed of the glacier was clearly revealed. Its fall caused a series of huge waves which rose on the coast nearby to a height of 110 feet, and on the north side of Haenke Island 115 feet (by Locke level), washing up and rending willows and alders at this elevation. At the point where we had photographed the glacier on the day before its fall the wave destroyed vegetation thirty feet above high tide. The Indians report that this same glacier slid out of its valley sixty years ago and killed a hundred Indians; but fortunately the Indians had left their summer sealing camp before July 4th, 1905, and no one was on Disenchantment Bay, otherwise there would certainly have been destruction of life.

RECENT RECESSION OF GLACIERS.—Most of the smaller glaciers studied show abundant evidence of recent recession, and it is evident that this shrinkage is still in progress. Unfortunately, we have no means of proving the exact amount or rate of this retreat, for in most cases there have been no previous records. The evidence of marked recession is, however, clear. It is in the form of moraine-covered ice remnants in front of the present ice termini (Fig. 22), and of barren areas in front of the ice, on which in some cases even annual plants have not yet taken root (Figs. 19 and 23).

For the larger glaciers the photographs by Russell and Gilbert and the maps by Gannett give us a basis for more exact comparison, and in some cases it was found possible to relocate the

sites of the photographs taken by these observers. In the case of the Hidden Glacier the site of one of Gilbert's pictures was determined rather closely, though the exact spot could not be found.* Both by this and by a plane-table map the amount of recession of the snout of Hidden Glacier between June 1899 and July 1905 is found to have been about a quarter of a mile.

The exact site of Gilbert's photograph of the sea end of Nunatak Glacier was located, even the stones in the foreground being identical in the two cases. These two photographs are reproduced as Figs. 13 and 14. In this case the recession between 1899 and 1905 is not far from a mile. The land end of the Nunatak Glacier has receded between an eighth and a quarter of a mile since 1899, and the Cascading Glacier has diminished perceptibly.

Recent Advance of Turner and Hubbard Glaciers.—Our photographs of the Turner and Hubbard Glaciers, taken from the sites of the photographs by Russell and Gilbert, were unfortunately not very successful, and our plane-table map does not definitely prove any change in the ice-front of these two glaciers. To show the present condition, marks were made on these earlier photographs while occupying the sites from which they were taken, and these show clearly a change in both glaciers. A comparison of our photographs with those of Russell and Gilbert shows fairly well the changes which we detected in the field.

In both of the earlier pictures the medial moraine in the ice-foot near the middle of Turner Glacier appears to turn northeastward; but in 1905 this turn is gone, and the much-shortened medial moraine advances straight into the fiord. This is taken as an indication that the sea front of Turner Glacier was in 1905 several hundred yards farther back than in either 1891 or 1899. This recession may possibly be related in origin to the violent earthquake of September, 1899, which is known to have profoundly affected the Muir Glacier, and whose effects in this fiord were stupendous, as will be shown in other papers. As compared with Russell's photograph of 1891, the two ends (north and south) of Turner Glacier front had in 1905 receded perceptibly; but as compared with Gilbert's photograph of 1899, the two ends have advanced slightly. The evidence, therefore, indicates for this glacier a general recession between 1891 and 1899 and a slight advance on the two ends between 1899 and 1905, but a recession in the centre.

A photograph taken in 1899 by Gilbert, on the south side of Hubbard Glacier, looking along the front of the ice-cliff, was dupli-

* See Fig. 15 and compare with Gilbert's picture in Harriman Alaska Expedition, Vol. III, Plate VI.

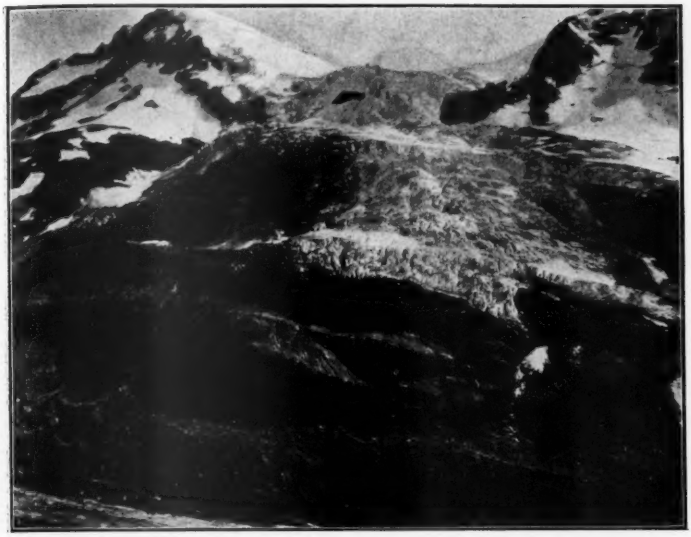

FIG. 9.—CASCADING GLACIER, JULY 24, 1905, FROM SOUTH SLOPE OF GANNETT NUNATAK, LOOKING SOUTHWARD. SHOWS STRONG GROOVING OF VALLEY SIDE, AND CASCADING GLACIER ISSUING FROM ITS HANGING VALLEY AND DESCENDING THE TERRACES. THE VERTICAL BANDS ARE THE RESULT OF STREAMS FLOWING DOWN THE CLIFF SIDE FROM THE GLACIER.

FIG. 10.—PITTED OUTWASH PLAIN BELOW END OF HIDDEN GLACIER. VIEW LOOKS NORTHWESTWARD. CAMERA STANDS ON HIDDEN GLACIER. GLACIATED TOPOGRAPHY AND ABSENCE OF VEGETATION ARE NOTABLE. VIEW TAKEN JULY 25, 1905.

cated as nearly as possible in 1905; but Gilbert's exact site could not be found. From this station it appears that the ice has receded, but the correctness of this conclusion is rendered uncertain because of doubt as to the exact location of Gilbert's picture. We could not, however, find any spot as near the ice as Gilbert's picture, and with the proper relation of beach to ice, where anything but recession could be inferred. On the other hand, from the Gilbert and Russell sites on Haenke Island, and from Gilbert's site on Gilbert Point* above Osier Island, it is evident that the northwest half of Hubbard Glacier has advanced between 1899 and 1905, though the exact amount cannot be stated. The evidence of this advance is that the northwestern end of the glacier on the land is farther out, and the medial moraine of the western tributary of the Hubbard Glacier now bends farther southward than in either 1891 or 1899. This suggests the possibility that the western arm of the Hubbard is advancing and the eastern receding.

One of our Indians, who hunts seal in the bay each year, was very confident that the Hubbard Glacier has been advancing for the last ten or twelve years; but our plane-table map, as compared with that of Gannett, does not support this view. However, with a short base-line, and with the great distance to the various points on the glaciers, small changes might not appear. Our study of the photographs made by Gilbert and Russell convinced us that there has been an advance of the northwestern part of the Hubbard Glacier, both as compared with the photographs of 1891 and with those of 1899. Our photographs will be published in the final report, where this subject is more fully discussed.

Former Extension of Glaciers.

That the glaciers of this region have at one time been much more extensive, and in fact have occupied the entire inlet, is clearly demonstrated by three important lines of evidence: (1) The Yakutat foreland; (2) the presence of high-level moraines on the mountain slopes; and (3) the evidence of profound glacial erosion. Each of these lines of evidence will be briefly considered.

These former greater ice streams will be spoken of as the Yakutat Bay Glacier and the Russell Fiord Glacier.

The Yakutat Foreland.—This broad foreland is so densely wooded over part of its area, especially near the shores, that its exploration is difficult. We entered it a short distance at several points, and at Yakutat went out upon it for about ten miles to the

* Named for Dr. G. K. Gilbert.

terminus of the Yakutat and Southern Railway. From the slopes of Mt. Tebenkof we gained, also, a good bird's-eye view of the foreland. From these examinations it was found that the foreland consists of two quite different classes of deposits. Near the shores of Yakutat Bay and south of the head of Russell Fiord it is distinctly morainic, with hummocks and kettles, some of them occupied by lakes and swamps. In this part of the foreland there are quantities of large crystalline boulders, evidently brought from far back in the St. Elias chain. Fringing these moraines to the south and east is a level plain, or prairie, free from forest over a great part of its area because the drainage is too slack for tree growth. This plain, sloping gently seaward, is made of outwash gravels, evidently of the same origin and general character as those now building along the margin of the Malaspina Glacier.

The evidence from the foreland points to the presence of moraine-building ice, filling both Russell Fiord to its head and Yakutat Bay clear to Yakutat, and building up the area intervening between the ends of the two glaciers with outwash gravels from each of the great glaciers. That during this expansion of the glaciers ice extended out to the present mouth of Yakutat Bay is indicated by the soundings, which show a general though irregular rise in the bottom of the bay from its head, where it is 1,000 feet deep, to its mouth, where the water is everywhere shallow, being nowhere over 100 feet deep and over most of the distance from 50 to 75 feet deep. This shoal forms a definite, narrow ridge completely across the mouth of Yakutat Bay. Just inside of the ridge the water rapidly deepens.

Exactly what relation this expanded Yakutat Bay Glacier bore to the Malaspina is not now clear. That the two must have coalesced is evident; and that the Malaspina Glacier dominated in the lower part of the bay is indicated by the west-facing, irregular coast of the eastern side of the bay and its series of islands. If the sea was then at its present level there must have been a continuous ice-cliff across the site of the present mouth of Yakutat Bay, and far to the westward along the front of the present Malaspina. Whether the Yakutat Foreland was begun as a deposit in the sea is not now certain; but it is clear that it was finished above sea-level, and apparently approximately at the present level. This conclusion is based upon the fact that so much of its surface is alluvial fan, which could have been made only above sea-level. That before the advance of the ice the foreland was higher than now is proved by the presence of submerged forests on the beach beneath the gravels of the foreland at the head of Russell Fiord.

FIG. 11.—KETTLE IN OUTWASH GRAVEL PLAIN IN FRONT OF HIDDEN GLACIER, CAUSED BY MELTING OUT OF ICE BENEATH THE GRAVEL. OVERRIDDEN, HIGHER LEVEL GRAVELS SHOWN ON THE RIGHT. NEAR MOUNTAIN BASE. THE ICE HAS LEFT THE VALLEY SO RECENTLY THAT VEGETATION HAS NOT YET OCCUPIED THE GRAVELS.

FIG. 12.—TERMINUS OF HIDDEN GLACIER, JULY 30, 1905, LOOKING SOUTHWARD. SHOWS ICE RESTING ON GRAVELS WHICH, FARTHER DOWN THE VALLEY, ARE DISTINCTLY OVERRIDDEN, ICE-ERODED AND MORAINE-VENEERED. IN THE MIDDLE OF THE PICTURE, NEAR THE MORAINE-VENEERED ICE MOUNDS, THE SNOUT OF THE GLACIER DESCENDS BENEATH THE OUTWASH GRAVELS. (FIG. 10.)

An interesting record of the termination of the expanded Russell Fiord Glacier is preserved in the fist-shaped expansion, outside the mountains, that constitutes the head of the inlet. Evidently the Russell Fiord Glacier had a bulb terminal where released from the confining walls of the mountain fiord, and water now occupies the area formerly filled with ice at the stage of the glacier's maximum extension.

HIGH-LEVEL MORAINES.—Moraine deposits and foreign rock fragments occur at various points on the mountainous slopes of the fiord, proving the former presence of ice at these elevations. At four points we determined as carefully as possible, by the use of the aneroid barometer, the elevation to which the ice formerly reached, being careful to select places where the complication of local valley glaciation could not enter.

The first of these was on the ridge west of Cape Enchantment, which rises over 3,000 feet above Russell Fiord. Here excellent moraine occurs up to 1,350 feet, and crystalline rocks, undoubtedly brought from outside the peninsula, at 2,000 feet. Glacial scratches were observed at an elevation of 2,700 feet; but since above 2,000 feet there were no rocks that could be proved to be foreign this is taken as the elevation to which the ice-flood rose at that point.

The second point selected was on the ridge south of Point La Touche at the entrance to Disenchantment Bay. Here an excellent moraine occurs at an elevation of 1,750 feet, and foreign boulders at 1,920 feet. In the bay a mile or two west of this there is a sounding of 167 fathoms, so that at this point, at the very head of Yakutat Bay proper, the ice was at least 2,920 feet thick.

Northwest of Point La Touche, on the west side of the head of Yakutat Bay, the third point examined, there is a perfect moraine terrace which has an elevation of 1,900 feet where developed on the mountain side above the Galiano Glacier, but descends to 1,675 feet in two or three miles toward the southwest—that is, toward the Malaspina Glacier.

This height of the ice would permit the Yakutat Bay Glacier, extending out of Disenchantment Bay, to pass through some of the low divides of Puget peninsula to join the Russell Fiord Glacier; and it is probable, also, that during this higher stage of the ice the glacier streamed across the divide between the Hidden and Nunatak valleys and the Alsek River valley. The ice-divides at the present time are put down on the Boundary Commission map as 3,000 feet, and this is, of course, much higher than the rock-divide. Moreover, the elevation of the ice in Russell Fiord (2,000 feet) is too far

down the fiord to represent its maximum elevation. In view of these facts, it seems probable that the ice currents readily passed across these low divides.

The fourth point where the elevation of the ice in its flood stage was measured is on the southwestern slope of Mt. Tebenkof, just east of Knight Island. Here a pronounced moraine terrace occurs at an elevation of 800 feet, and foreign fragments were found up to 1,060 feet. This point is directly above the Yakutat Foreland and about fifteen miles from the outermost moraine of the foreland near Yakutat.

GLACIAL EROSION.—The evidence of profound glacial erosion in this fiord is clear and convincing. On the east shore of Yakutat Bay, where the valley broadens rapidly, this evidence is not very strong; and near the head of Russell Fiord, toward the end of the tongue which filled that valley, so far as can be judged from the character of the valley sides, there was evidently little glacial erosion. But in Disenchantment Bay, most of Russell Fiord, Nunatak Fiord, and many minor valleys, the evidence of ice erosion is of the most definite character. Its clearness is rendered all the more striking because of the almost complete absence of vegetation, and the general thinness of drift (Figs. 15 and 16).

One is prepared for a belief in vigorous ice erosion by the prominence of striated rock surfaces and *roches moutonnées* forms on the fiord walls. This erosion often assumes the form of a distinct grooving, by which the valley walls are sculptured nearly horizontally into terrace-like steps descending gently in the direction of ice motion. This sculpturing is at times coincident with differences in rock texture, but is often independent of it. The photograph of the Cascading Glacier (Fig. 9) well illustrates this type of sculpturing. There is terrace above terrace carved in the rock wall of Nunatak Fiord when the greater glacier flowed out of it at the time of a higher stand of the ice. The Cascading Glacier descends from terrace to terrace, with direction of flow at right angles to that of the former ice-tongue whose groovings it has been incompetent to destroy. So recent has been the last stage in this erosion of the Nunatak valley that near the glaciers the rock surfaces a thousand feet above the fiord are smoothed and striated, and glisten in the sun as their polished faces reflect the sunlight.

Where the rocks are fairly firm, but much jointed, notably in the granite cliffs on the south shore of Nunatak Fiord, the evidence of plucking is very pronounced. In such places the rock cliffs are rough and hackly as a whole, but in detail are found to consist of a

FIG. 13.—GILBERT'S PHOTOGRAPH OF NUNATAK GLACIER, JUNE 21, 1899. COMPARE WITH PHOTOGRAPH JULY 24, 1905. (FIG. 14.)

FIG. 14.—NUNATAK GLACIER, JULY 24, 1905. TAKEN FROM EXACT SITE OF GILBERT'S PHOTOGRAPH, JUNE 21, 1899. THE SAME BOULDERS APPEAR IN BOTH PICTURES. COMPARE WITH FIG. 13.

series of rounded, glaciated curves and angular fractures, indicative of both scouring and rending as the processes by which the valleys were broadened and deepened.

Associated with these evidences of powerful erosion are a series of wonderfully perfect hanging valleys, many of them occupied by glaciers, in some cases down to their very lips. The best of these valleys hang from 500 to 1,000 feet above the surface of the fiord water, and from their lips extend back into the mountains as broad, U-shaped troughs, themselves evidently broadened and deepened by glacial erosion. Where these deep, broad, discordant tributaries come to the very edge of the fiord wall, they end abruptly as wide-open valleys hanging high up above the main valley bottom (Fig. 17.)

The streams flowing out of them cascade down the fiord slope usually in a narrow gorge, but sometimes as a series of cascades on the very face of the fiord wall. The anomaly of such a valley—a broad, moderately-sloping upper part, and a narrow, steeply-sloping gorge below—is too well known to require further description; and the photographs (Figs. 14, 15, 17, and 18) illustrate it well.

The hanging valleys themselves often have tributary hanging valleys, proving that while the main valley was deepened more than the laterals, these were deepened more than their tributaries. In each case the valley wall below the level of the hanging valleys is straight, smooth, and steep, and this condition usually extends well above the level of the hanging valley. But in all cases where there are hanging valleys, the walls of the main valley exhibit striking evidence of glacial erosion up to a certain level, while above it the valley wall is made irregular by weathering and erosion of the type characteristic of subaerial work (Fig. 16).

In the steepened, ice-eroded lower slopes there are no spurs and no pronounced valleys, and the streams descending from the higher part of the mountain flow in numerous, closely-spaced parallel courses, usually on the very face of the valley wall, and never in other than shallow gorge valleys. The entire condition of valley slope and drainage development is immature, and totally out of harmony with the breadth and depth of the main valley, as well as with the topography above the steepened slope.

The hanging valleys are not hanging at a uniform level, nor is there any regular decrease in level noticeable down the fiord. The difference in level appears to depend in the main upon the relative power of ice erosion in the valleys. Speaking generally, the smaller the valley the higher it hangs above the main valley floor.

The resistance of the rock is another factor of importance; and it is a notable fact in this connection that the valleys hanging highest above the sides of the fiord are in the region of crystalline rocks, while those entering the fiord in the weaker Yakutat Series are hanging at much lower levels. As would be expected as a result of differential ice erosion, there is every gradation from the high hanging valleys to those with lips at or below the fiord-level; and the larger valleys admit the sea into their mouths, as in the case of Seal Bay and Nunatak Fiord. It is to be expected that these will also be found to be hanging above the fiord bottom when soundings have been made.

The proof that hanging valleys in glaciated regions are significant of ice erosion is now so well established that it is hardly necessary at this time to consider the question whether these phenomena in the Yakutat Bay region may be due to another cause than ice erosion. The facts all harmonize with the explanation of ice erosion, and are totally out of harmony with any other explanation that has so far been proposed. Even with the clear evidence presented in this region that as late as 1899 faulting has occurred along the axes of some of the valleys, the hypothesis that the hanging valley condition is the result of faulting seems absolutely untenable. It could not account for the difference in level of neighbouring hanging valleys; for the hanging tributaries of main hanging valleys whose rock lips show no signs of faulting; for the residual nunatak knobs on the sides and in the middle of the fiords; nor the flaring fiord walls.

The peculiar condition of lowered divides, common in Puget Peninsula and between Russell Fiord and the Alsek River valley, which makes possible the presence of through-glaciers in these situations, is interpreted as the result of the reduction of divides by ice erosion when the glaciers were of greater extension, and therefore able to stream across the lower divides. Such broad, transverse valleys in the midst of a rugged mountain region seem out of harmony with the rest of the topography, and with the dominant direction of drainage. Some of the lower through-valleys near the fiord, in which there is little or no ice at present, show evidence of vigorous ice-erosion; but the larger ones are still so deeply buried beneath ice that their characteristics are in large part obscured. Their lack of harmony with the erosional forms of the surrounding mountains proves that they are not wholly the result of subaerial erosion; the theory of block faulting is wholly gratuitous, and, in the case of the visible through-valleys, evidently not applicable. To the ice-erosion theory no strong objection appears, and it is therefore proposed in explanation of this phenomenon.

Evidence of Interglacial Stage.

Gravel Deposits.—Along the shores of various parts of the inlet there are gravel deposits forming low, irregular terraces. It is not certain that they are all of a single age, but they all have the same characteristic*; and they occur all the way from the foreland up to and under some of the glaciers, notably the Hidden Glacier (Fig. 12). These gravels lie for the most part within one or two hundred feet of sea-level. Viewed at a distance, and in general, they often assume the form of terraces (Fig. 19); but when looked at in detail they are found to be undulating and not of a uniform level. Evidence is presented below to show that they are remnants of more extensive gravel deposits overridden by ice after their accumulation and partly removed by the ice-erosion. They bear no recognizable relation to existing sources of gravel, not being, for example, better developed opposite large streams. Their most typical development is in the south arm of Russell Fiord, and there they rise to a level rarely higher than 250 feet. The larger remnants occur in places where the topography suggests the possibility of weaker ice-erosion than in places where they are entirely absent.

Numerous cuts, both by streams and waves, clearly reveal the composition of the gravels in many places. They consist of cross-bedded gravels (Fig. 20) with many sand layers and occasional beds of clay, and the general dip of the layers is toward the fiord; but in many cases it is along the axis of the fiord and downward away from the ice source. The pebbles are in the main of crystalline rocks, well rounded, both of which facts indicate long transportation. They are strikingly unlike the gravels of the alluvial fans now forming near them, in which the pebbles are prevailingly of local Yakutat Series rocks and only slightly rounded. In the gravels are numerous large boulders, which must have been drifted to their place in floating ice. No animal fossils were found in the clays.

Evidently these gravels were deposited in a former, higher water body, in which ice could float boulders hundreds of pounds, and in some cases tons, in weight. Such a water body must have existed in Russell Fiord when the glaciers advanced far enough to cut it off from Disenchantment Bay, as explorations over 100 years ago indicate they did; smaller bodies of water marginal to the ice may also have existed here and in other parts of the bay. Into these water bodies glacial streams apparently built outwash gravel deposits as the ice was receding from its former maximum advance. That the

* There are also higher level gravels not considered here.

period of their building was not long ago is proved by the fact that the gravels are not at all disintegrated.

The period of gravel-building evidently lasted a long time, and under conditions different from the present, for in the gravels are frequently found fragments of trees in a region where no trees now grow. Most of these trunks are recumbent, but in one place they are standing where they grew (Fig. 21), buried in the gravels. In this case the trees were mature in age, their bark was preserved, and cones occurred in the clay layers in which the trees grew. One recumbent log was found in the gravel terrace of the Hidden Glacier valley, about a mile from the present ice terminus, and fully twenty miles from the nearest trees at present growing in the fiord. Our collections of wood have not yet been identified, so that it is impossible at present to tell the nature of this forest growth. It indicates, however, a long period for the formation of the gravel deposits, and the presence of conditions favouring tree growth in a region where no trees now grow. The variation of conditions which caused first coarse gravel deposition, then tree growth to maturity, then re-establishment of conditions of gravel deposition, is indicated in the present alluvial fan of Atrevida Glacier, where fluctuation of stream course and of load are to-day resulting in clay deposit in one place, and in another, the burial of a living forest, while near-by a degrading stream is uncovering a forest previously buried.

Some of the recumbent trees may have been brought to their position by the ice of the maximum advance and therefore represent a part of the preglacial forest, though this does not seem probable in view of the evidence of marked ice-erosion, which should have removed the forest and carried its remnants out to the moraine of the foreland. Moreover, the abundance of these recumbent logs seems too great for this explanation. Wave dissection is now carrying off the logs of these buried forests, and they are being built into driftwood piles on the beaches. This is well seen at the head of the bay, where no modern forests of mature growth are reached by the waves. Consequently one's camp fires are fed by the wood of the last interglacial epoch before the present.

Re-advance of the Ice.—A number of facts prove that these gravels have been overridden by a glacier since their deposit. In the first place, as has been already stated, the gravels extend up to some of the glaciers, and in at least two cases the ice rests directly on the gravels. The best instance of this is at the Hidden Glacier (Fig. 12), already described; but a valley glacier on Puget peninsula just southwest of Cape Enchantment has also overridden its gravels (Fig.

FIG. 17.—HANGING VALLEY ON SOUTH SIDE OF NUNATAK FIORD. VIEW LOOKS SOUTHWARD STRONGLY GLACIATED SLOPES, RECENTLY ABANDONED BY ICE AND WITH ALMOST NO VEGETATION.

FIG. 18.—HANGING VALLEYS ON NORTH SIDE OF THE BROAD U-SHAPED GLACIATED RUSSELL VALLEY ON PUGET PENINSULA. VIEW LOOKS NORTHEASTWARD UP THE VALLEY. THE VALLEY BOTTOM IS LEVELLED BY OUTWASH GRAVELS DERIVED FROM A SMALL GLACIER AT THE HEAD OF THE VALLEY, ONE OF WHOSE RECESSIONAL MORAINES APPEARS IN THE LEFT CENTER.

22); and in other cases the same condition is apparently present, though the evidence is not quite so clear.

A second proof of overriding of the gravels is the topography of the terraces. Being water-laid gravels, their constructional surface must have been a plain, determined by the water surface into which they were built and by the stream grade which was supplying the gravels. They no longer have the form of a plain, but have instead a gently-rolling surface which truncates the gravel layers. Some erosive force has removed a part of the gravels. It is not wave action, which would have cut a terrace; nor is it stream erosion, which would have cut gorges down toward a base-level. The erosive force has given the surface of the gravels an undulating outline, often broadly grooved parallel to the axis of the valley, and hence at right angles to the direction in which stream erosion would dissect them. The surface form has the appearance of an ice-eroded surface, and many miles away from the present termini of the glaciers is identical with that of the gravels of the Hidden Glacier valley, from which the ice is known to have retreated within the past six years.

Associated with this ice-erosion topography is a veneer of moraine resting on the surface of the gravels. In places the moraine is represented only by scattered boulders; but very frequently there are morainic hummocks and ridges, often enclosing kettles in which at times ponds are held (Fig. 24). Where best developed the gravel deposits have the appearance of a very thick moraine; but stream and wave cuts prove that even there the condition is really that of thick, eroded gravel beds with a thin morainic veneer. The morainic forms present some very interesting characteristics, one of the most notable being the linear disposition of assorted boulders and of moraines, resulting, evidently, from accumulation in crevasses during the final melting of the ice. There are also kame areas, and occasional eskers of small size resting on the gravels (Fig. 23).

That the gravels have been overridden by ice admits of no doubt; but the overriding did not extend the whole length of the fiord. In the southern half of the south arm of Russell Fiord the gravels have a level surface up to an elevation of about 140 feet, and on it there was found no evidence of overriding either in the form of ice-eroded surface or of moraine veneer. Above the level of 140 feet the surface is of a pronounced moraine. It is therefore inferred that the re-advance of the ice extended about half way to the head of the southeastern arm of Russell Fiord, and that the waves of an ice-dammed lake, held up in the southern part of the fiord, formed the gravel bench which exists there at an elevation of about 140 feet, by planing off the morainic deposits.

For the phenomena described in this and the preceding section two possible interpretations present themselves: (1) The advancing glaciers of the great ice flood made the gravel deposits, then overrode them, but failed to remove them; (2) the recession of the great ice advance, or a recent re-advance, or both, were accompanied by gravel deposit, and the re-advance overrode a part of the gravels, but did not last long enough to completely remove them. Unfortunately, the platform on which the gravels rest was nowhere seen, so that direct evidence from this source is not available. The reason for considering the first explanation impossible is indirect, but seems to the authors convincing. It is that, if the gravels were formed in front of the ice in the main period of advance and then overridden by it, they must surely have been removed by erosion. If our conclusion that there has been profound ice-erosion in the fiords is correct, the extensive gravel deposits surely could not be left where they now stand. Some of them in Nunatak Fiord lie directly beneath the lip of a hanging valley; and others in Russell Fiord extend across the mouth of a hanging valley. Even without the assumption of such profound ice-erosion as is believed to have been accomplished in this region, it seems inconceivable that ice over 2,000 feet thick, and 25 miles from its terminus, could have passed over gravels for a long enough time to build the great Yakutat Foreland and yet not remove a series of gravels, especially in view of the scratched, grooved and plucked rock cliffs, indicating that the ice was a powerful erosive agent. The wonder is that even a brief advance of the ice, extending part way through the fiord, should have left such extensive accumulations of gravel. But this is not the only region where the evidence indicates earlier powerful glacial erosion and later weaker advance failing to remove gravel and even products of residual decay.

This evidence, though indirect, is therefore advanced as proof that the gravels were formed subsequent to the great ice advance, and that they were very recently overridden by another advance which extended part way through the fiord but did not last long enough to erode the gravels formed at an earlier stage. That the recession of the ice from these gravels, now actively in progress, is very recent is indicated by the vegetation, as stated below. Without much doubt this advance was the one which stopped the explorations of Malaspina in 1792 and Puget in 1794, when they found Disenchantment Bay blocked by ice down as far as Haenke Island.*

* It is noteworthy that the succession worked out in the Yakutat Bay region is almost identical with that demonstrated for the Muir Inlet region by Wright, Reid, and Cushing.

FIG. 15.—LOOKING SOUTHWARD ACROSS HIDDEN GLACIER VALLEY, JULY 26, 1905, SHOWING EXTREME END OF FRONT OF GLACIER ON THE LEFT. COMPARE WITH GILBERT'S PICTURE (HARRIMAN EXPEDITION, VOL. III, PL. VI) TAKEN FROM NEARLY THE SAME SITE, BUT A LITTLE FARTHER BACK. SHOWS A BROAD MOUNTAIN VALLEY TERMINATING BELOW IN A GORGE.

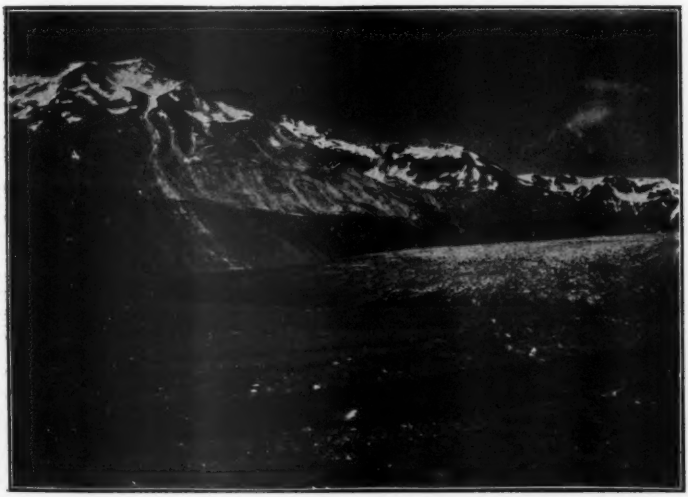

FIG. 16.—TERMINUS OF HIDDEN GLACIER, JULY 25, 1905, LOOKING NORTHEASTWARD FROM A SMALL ROCK KNOLL RISING ABOVE GRAVEL PLAIN ON SOUTH SIDE OF VALLEY. SHOWS THE GRAVEL PLAIN BENEATH WHICH THE ICE DESCENDS; AND THE OLDER GRAVELS ON THE NORTH SIDE ON WHICH THE ICE NOW RESTS; ALSO STRONGLY GLACIATED TOPOGRAPHY AND ABSENCE OF VEGETATION.

FIG. 19.—DISSECTED GRAVEL TERRACES ON THE NORTH SIDE OF NUNATAK FIORD, ABOUT TWO MILES BELOW THE SEA END OF NUNATAK GLACIER. THESE GRAVELS HAVE BEEN OVERRIDDEN BY THE ICE AND BEAR A VENEER OF MORAINE. VEGETATION HAS NOT YET OCCUPIED THEM.

FIG. 20.—SECTION IN THE OVERRIDDEN, MORAINE-VENEERED GRAVELS ON THE WEST SIDE OF THE SOUTH ARM OF RUSSELL FIORD. VIEW LOOKS SOUTHWARD AND IN THE DISTANCE SHOWS THE OVERRIDDEN GRAVEL AREA ON THE EAST SIDE OF THE FIORD, JUST NORTH OF RUSSELL COVE. (SEE ALSO FIG. 24.) ONLY SCATTERED ALDERS AND OPEN THICKETS HAVE ADVANCED THUS FAR NORTHWARD.

Advancing Vegetation of Yakutat Bay.—In 1892 Funston collected plants in Yakutat Bay up as far as Haenke Island; but no detailed botanical study, so far as known, has been made beyond this point. In variety of species present the region is not an inviting one, but in distribution of plants the field is most attractive; for it is a region from which the ice is even now receding, and in which one may note the advance of a flora upon a land newly opened to plant occupation by ice withdrawal. Unfortunately, none of our party was trained as a botanist, and other duties prevented the collection of plants; but some general features were so noticeable that they could not escape attention.

The Yakutat Bay region presents two entirely opposite conditions of vegetation. On the one extreme is the typical dense Alaskan forest; on the other, a desert (Figs. 16, 19, and others). The forest clothes the foreland and the lower mountain slopes at the head of Russell Fiord and on the border of Yakutat Bay. In the damp, equable climate the vegetation grows luxuriantly and the forest is dark, damp, and difficult to penetrate. It is mainly of Sitka spruce, with individuals 70 feet high. Much less abundant is the hemlock. In favourable situations the cottonwood grows, in places forming forests, with little or no spruce in it. According to Funston, the spruce rises to an altitude of 2,200 feet on the sides of Mt. Tebenkof; but the timber-line descends toward the interior, reaching sea-level in Disenchantment Bay. In the narrower Russell Fiord the forest reaches less than half way northward from the head of the inlet toward Cape Enchantment.

Between the forest and the desert there is an area occupied by alder and willow, which grow in such an intricate tangle as to make passage a most difficult task, rendered exasperating by the presence of the thorny devil's club. The same type of growth occurs on the mountain slopes above the forest zone. This alder tangle occurs in many valleys of the peninsula, along both shores of Russell Fiord just north of the forest zone, along the shores of Disenchantment Bay, and in a part of the stretch of Russell Fiord between Gilbert Point and Cape Enchantment. It is absent from Nunatak Fiord, and from most of Russell Fiord between Marble Point and Seal Bay.

The desert is in part the result of rugged mountain, snowfield, and ice conditions; in part it is caused by the presence of moraine-veneered ice with a shifting soil, and of alluvial fans now building; but over large areas the desert condition is due to the fact that ice has so recently left the land that woody plants have not found time to occupy the soil. This is especially true between Marble Point and

Seal Bay, including Nunatak Fiord (Figs. 17 and 19). Here the alder and willow have begun to grow, but, excepting in a few spots, have not succeeded in developing the characteristic, almost impenetrable thicket. Nearest to the ice of the Nunatak and Hidden Glaciers no alders or willows grow, but between the glaciers and the area of alder thickets are individuals and clusters, increasing both in size and abundance away from the ice.

There can be no question that vegetation is following up the receding ice, and that its stages of advance are here plainly recorded. The ice is receding faster than vegetation can advance, and light-seeded alders and willows have pushed farthest forward. That the forest trees have not advanced as far as is possible under existing climatic conditions, and that the forest is now marching toward and into the desert area, is indicated by a number of facts. In the first place, the climate is apparently favourable. We have not climatic data to prove this beyond question; but the summer from the first of July to the first of September is certainly favourable; and, even with the neighbourhood of glaciers and snow-clad mountains, it seems improbable that the winter cold here can be too severe for trees, for the area is near the warm ocean, open to its influence, and is bathed by fiord waters. In the second place, the limit of tree growth is not marked by stunted trees, as is the upper limit of tree growth on the mountains. Well-formed and good-sized spruces and cottonwoods mark the northern limit of the forest, which could hardly be the case with a forest limited by adverse conditions. Furthermore, the light-seeded cottonwood is in advance of the heavy-seeded spruce. Finally, both spruce and cottonwood in scattered individuals occur well in advance of the forest. Scattered young cottonwoods occur within a few miles of the present terminus of the Nunatak Glacier, and there are two or three young spruces, estimated to be fifteen or twenty years old, growing on Haenke Island. Funston in 1892 reported that there were no spruces in Disenchantment Bay; but in 1905 there certainly were several spruces as far up this bay as Haenke Island.

There is in this bay a splendid chance for an interesting ecological study; and it ought to be made now, for purposes of comparison at some future time. Not only is there this general problem, but also the very interesting phenomenon of the growth of vegetation on the moraines of living ice.

The Fauna of Yakutat Bay.—No attempt was made to study the fauna of the region, and it is not the purpose here to give a list of even those animals observed, but merely to point out the evidence

FIG 21.—FOREST BURIED IN CLAY BED IN GRAVELS, NEAR SOUTH END OF RUSSELL FIORD. THE HEAD OF THE BAY IN THE DISTANCE, WITH STRAWBERRY ISLAND ON THE RIGHT. THE MAN STANDS NEAR ONE OF THE BURIED TREES. VIEW LOOKS SOUTHWARD.

FIG. 22.—LOOKING NORTHWARD ALONG WEST SIDE OF SOUTH ARM OF RUSSELL FIORD, JUST SOUTH OF CAPE ENCHANTMENT. OVERRIDDEN, MORAINE-VENEERED GRAVELS FORM THE FOREGROUND AND THE RIGHT MARGIN OF THE PICTURE. THE GRAVELS ARE REVEALED IN A STREAM CUT IN THE MIDGROUND, AND BACK OF IT IS MORAINE-VENEERED ICE (LIGHT-COLORED), RESTING ON THE GRAVELS. VEGETATION HAS ONLY BEGUN TO REOCCUPY THIS OVERRIDDEN AREA.

FIG. 23.—SMALL ESKER ON THE RIGHT AND EXTENDING UP TO THE MAN AND THENCE SWINGING TO THE LEFT; RESTING ON THE OVERRIDDEN GRAVELS (FIG. 19) ON NORTH SIDE OF NUNATAK FIORD.

FIG. 24.—LOOKING SOUTHWARD UP THE SOUTH ARM OF RUSSELL FIORD ON THE WEST SIDE. THE OVERRIDDEN GRAVELS NEAR RUSSELL COVE SHOW ON THE LEFT. THE FOREGROUND SHOWS MORAINE OF RECENT ICE ADVANCE. AN ALDER THICKET HAS ADVANCED THUS FAR NORTHWARD, OCCUPYING THE AREA FROM WHICH ICE HAS RETREATED. SOUTH OF THIS THE ALDER GROWTH BECOMES MORE EXTENSIVE, THE REGION HAVING BEEN LONGER FREED FROM ICE.

that the fauna, as well as the flora, has not yet advanced to occupy the regions recently ice-covered. It would be most interesting if this statement could be extended to include the marine life as well, which would doubtless show similar conditions.

One fact of general interest is that the deer, abundant farther south—around Sitka, for example—have not passed the ice barriers and migrated to the Yakutat Foreland, where conditions for their existence are most favourable. The mountain sheep, black and brown bear, wolf, fox, marmot, and some smaller mammals do, however, occupy the region.

Within the area of the Yakutat Bay region itself there is proof of the effectiveness of the ice barrier to the progress of mammals. Puget Peninsula abounds in foxes, and wolves; and both here and on the mainland to the east and west, black and brown bear are abundant. None of these animals were seen in the region between the Nunatak and Hubbard Glaciers; nor were their tracks, very abundant elsewhere, seen there. In harmony with this scarcity, and apparent complete absence, of these mammals from that particular area are two facts pointing to the conclusion that they have not occupied this section. In the first place ptarmigan, which are an easy prey to carnivorous animals, are exceedingly abundant there; in fact we called this the Ptarmigan Coast, and to it sent our natives whenever we wanted a supply of these birds. In the second place, the gulls nest on the ground on the moraine of the Variegated Glacier, while elsewhere in the inlet they build nests on the cliffs in places as nearly inaccessible to foxes as possible.

The extensive ice area of the Nunatak and Hubbard Glaciers, which are badly crevassed, the lofty intervening snow-capped mountains, and the water barrier of the fiord seem to have acted as effectual barriers to the spread of carnivorous mammals to this shore of Russell Fiord. But even these barriers, as at present existing, could hardly have been completely effective for a long time; and the evidence from other directions proves that the ice barrier is now of far less importance than formerly, and that, with its partial removal by recession of the glaciers, the area of unoccupied land has been recently greatly increased.*

* As at first written this article was prefaced by a general description of the region and a review of the literature; but it became necessary to omit this portion. This is the explanation of the failure to refer more specifically to Russell's splendid pioneer work and to his papers—Nat. Geog. Mag., Vol. III, 1891, pp. 53–203; 13th Ann. Rept. U. S. Geol. Survey, 1891–2, Part II, pp. 1–91—to which we are greatly indebted. Reference should also be made to Frederick Funston's paper—Contributions from the U. S. National Herbarium, Vol. III, No. 6, 1895, U. S. Dept. Agriculture.

THE BUFFALO RIVER: AN INTERESTING MEANDERING STREAM.

BY

ROBERT F. GRIGGS.

The Buffalo River is a swift trout brook rising in Buffalo Lake about twelve miles north of Detroit, Minnesota, and flowing southwest to Muskoda on the shore-line of the ancient Lake Agassiz, where it turns in a northwesterly direction across the old lake bottom till it joins the Red River of the North near Georgetown.

By the direction of its flow, its velocity, and the behaviour of the river itself, it is divided into halves, quite distinct from each other. The upper portion flows off from the "Height of Land" down to the level "Red River Valley," and has a steep gradient, amounting, in the twelve miles between Hawley and Stockwood, to 200 feet, while the lower slope is only about one fourth as steep. Consequently, the upper portion is much swifter than the lower, and babbles along over the rocks in its bottom with a noise which can be heard for a quarter of a mile. The upper river cuts banks of sandy drift from which clay is almost absent. Its course is full of sandbars and obstructed by many boulders, but its water is usually clear and sparkling. Contrasting with this is the sticky gumbo clay of the Red River Valley through which the lower reaches flow. This is only with difficulty taken up by running water, and is then in a finely-divided state, giving the water the turbid appearance characteristic of the streams of the region. This gumbo, once in suspension, settles out but very slowly, so that there are no deposits in bars and the like along its bed, but its channel is swept deep and clean like a canal.

The upper portion furnishes the most remarkable example of a meandering stream the writer has ever been fortunate enough to observe. The swift water working on the soft gravel has a cutting power (or, better, *carrying power,* for there is no cutting to be done) which is almost unbelievable. Everywhere the channel is shifting with extraordinary rapidity as the stream meanders about on its flood-plain. The plate shows a set of meanders near Muskoda which show very well the general character of the upper portion of the river. To the left is a meander in process of being cut off, while in the centre are shown remnants of three former meanders long since cut off and now nearly filled up. A set more striking in its contor-

tions and in the number of cut-offs in process of formation, but sufficiently obscured by brush to render photography impracticable, is shown in Fig. 1, which was sketched from a high hill overlooking the stream about five miles farther up-stream than the plate.

To this habit of rapidly meandering from side to side in its flood-plain the lower river offers a strong contrast. Like all streams of the Red River Valley, it is extremely crooked; but its crooks are relatively stationary, not rapidly shifting. Though bends often approach quite close to each other, cut-offs are of rare occurrence. Frequently the river is actively cutting on both sides of its bed, and deposition, such as is a necessary part of meandering in filling up the cut-offs, is entirely insignificant. There is no flood-plain, but the crooks are deeply sunken into the plain over which the river flows. They belong, therefore, to the class of entrenched meanders.

It seems desirable at this point to call attention to some looseness in the application of the

PLATE 1.—MEANDERS IN BUFFALO RIVER AT MUSKODA, MINNESOTA.

term *meandering*. Frequently by a meandering stream is meant simply an unusually crooked one, but if we recognize meander as the *process* which is described in the text-books under that name, we must limit the term to streams in which the process is going on. In other words, a meandering stream is not simply a stream which happens for any reason to be crooked, but one which is *actively* meandering—*i. e.*, alternately cutting and building out its banks so as to become progressively more and more crooked till it finally breaks across the bends and straightens itself for the time being.

In being at the same time a swift stream and one meandering rapidly the Buffalo is an exception not only to the ordinary phenomena of stream action, but also to the statements of the laws which have hitherto been enunciated as controlling the formation of meanders. For it is commonly believed and frequently asserted that

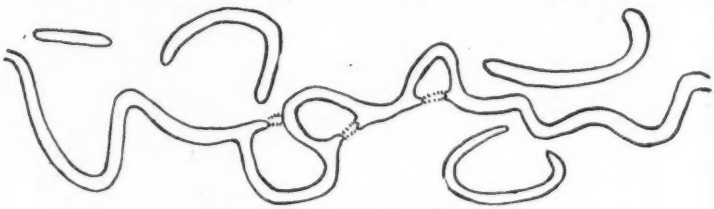

FIGURE 1.

meandering is possible only in sluggish streams. Russell* says, "Swift streams are not so easily turned aside as those which flow less impetuously. Hence the former maintain straighter courses than the latter." In the most recent work upon the subject—Chamberlin and Salisbury's Geology†—the same law is stated as follows: "A stream with an alluvial plain is likely to meander widely. In general terms this may be said to be the result of low velocity, which allows it to be easily turned aside." And a few sentences further on: "Even small creeks at high altitudes may meander if so situated as to have slight velocity. Trout Creek in Yellowstone Park is an example." The fact that such has been the statement of the law, and that it has met with wide acceptance, is sufficient evidence that it holds good in the great majority of cases. But, compared with other rivers, the Buffalo can hardly be said to have a low velocity, so that its crookedness must be accounted for in some other way. Since the laws of nature do not admit of exceptions, the statement of the

* Rivers of North America, p. 35, 1898. It should be noted in this connection that Mr. Russell's terms are not absolute but relative, and it is not impossible that his idea of a swift stream and the writer's differ widely.

† Vol. 1: 180-182. 1904.

law of meandering must evidently be at fault and require revision in order that it may cover both the ordinary slow meandering river and such as the Buffalo.

Let us look at the law *à priori* and examine it somewhat. Meanders are usually explained as follows: A stream is never exactly straight, and, if it were, some irregularity in the weathering of the banks or the side swing given by the entrance of a tributary would soon disturb its course and make it vary a little from a straight line. But at the same time the momentum of running water is very great, so that it resists vigorously any obstruction tending to deflect its course; and if forced to turn a corner, loses a considerable part of its power, which, of course, is expended in friction against the obstruction—in the case of a river, the outside bank of the bend. Thus it is that the outsides of the bends are cut away, and, as time goes on, the bend grows more and more crooked. This effect is further increased by the rebound of the current, which throws the water against the opposite bank, which in turn is cut away, so that all the little irregularities in the course of the stream tend to be accentuated and increase. Thus we see—paradoxically, indeed—that the very fact that water tends to flow in a straight line leads to its working out for itself a crooked channel. It is not easy to see how this general reaction of water could be affected by the velocity of the current, and it would seem difficult to fix a limiting velocity beyond which the tendency to meander would vanish in the case of a stream of a given size. On the contrary, it would appear from *à priori* grounds that the higher the velocity, the greater the force working on the outsides of the bends, and, consequently, the greater the rapidity in the formation of meanders. Thus we seem to be led to a conclusion exactly the reverse of that stated by the authorities cited—namely, that in the lateral wandering of a stream, as in most other lines of activity, other things being equal, the power is a function of the velocity, and that with every increase in the velocity comes a corresponding increase in the effect of the force acting.

That this conclusion has some justification in fact may be seen from the Buffalo River; for it is in the swift upper portion that the forces which cause meandering are most active and meanders best developed. In the lower portion, though the velocity is lower, lateral wandering goes on only very slowly, even where the stream is not sunk below the level of the country. This eliminates low velocity from consideration as one of the causes of meandering; for were it a conditioning factor in the process, we should certainly see some relation between the speed—or, rather, the sluggishness—of the

stream and its meandering. This is nowhere evident; and we shall have to pass on to the consideration of other possible causes.

But even though this is true, it is beyond question that the authorities quoted are correct in their statement of facts as far as most streams are concerned. Most commonly it is only sluggish streams that meander. If, then, there be no reason theoretically to prevent them, why is it so seldom that swift streams meander? A clue to this question may perhaps be obtained by a comparison of some other features of the streams in question. If we compare the valley of the Buffalo with those generally occupied by meandering streams on the one hand and with those of ordinary swift streams on the other we shall see some points of similarity and of difference which may be very instructive.

Most swift streams are young and flow in narrow cañons, while meandering streams occupy open valleys with broad flood-plains. The cañon is usually cut in hard rock very resistent to erosion as compared with the soft alluvium of the flood-plain. This difference suggests that the tendency to meander may be overcome by the hardness of the banks. But a meandering river is frequently seen slowly widening its flood-plain by cutting away the rocky bluffs at the sides, so that we must at once admit that a stream can cut in a lateral direction even into hard rock. Still, it is evident that in a cañon such cutting is neutralised by the much more rapid downward cutting, while in the broad alluvial valley downward cutting is almost at a standstill. Where a stream is rapidly digging downward and is entrenched in a cañon, it must remove a relatively enormous amount of material for every foot of side swing as compared with a river on a flood-plain. This makes lateral cutting very slow. Further, if it works downward very rapidly, it cannot develop any flood-plain, and so is prevented from suddenly shifting its course—an essential characteristic of meandering streams. This would suggest that meandering is in some way dependent upon the ratio of the downward to the lateral cutting power of a stream, and that it is because the downward cutting in most swift streams is very rapid as compared with the sidewise that meandering is rendered impossible. Upon what, then, does this ratio depend?

Perhaps one of the most conspicuous differences between a river in a cañon rapidly cutting downward and one meandering on a flood-plain is the relative load carried. The ratio of suspended matter to the power of transportation is much smaller in the swift stream, even though the absolute mass be much greater, because of the well-known law that the transporting power of running water increases

as the sixth power of the velocity. The scarcity of sandbars and alluvial deposits in cañons, even though the velocity is subject to enormous variations, while with every slight check the meandering river builds up a bar, is a sufficient demonstration of this fact. This difference arises partly because the transporting power of a swift stream is so enormous that it is well nigh impossible in the course of nature for it to receive enough waste to keep it busy, and *partly* because of the differences commonly present in the beds of the two classes of streams, swift torrents working over hard resistent rock, and sluggish rivers washing soft alluvium which crumbles as soon as wet. The work of a stream, whether it consists of moving solid particles of débris along its course or in wearing away the bottom of its bed and cutting downward, requires the expenditure of energy. Now, all the energy of a river is derived from the force of gravity acting on the water flowing down an inclined plane. This energy has a perfectly definite value for any slope, and can be used only once. It would, therefore, seem apparent that if a stream used up all its energy for the transportation of material supplied to it, it has no force left with which to abrade its bed. Consequently, a stream's power of deepening its channel depends on the ratio of load carried to its transporting power.*

While the load remains relatively small, channel-deepening goes on actively; but as soon as the stream becomes overloaded from any cause, it immediately stops cutting its bottom and begins to build it up, as, for example, in an alluvial fan, of which the various types of filled valleys are modifications, due to local conditions. When overloading is carried to an extreme possible only with a granular load like sand, which is not readily compacted and, after deposition, is full of interstices to hold the water, almost the entire force of the current may be expended in the effort to keep its load moving, and the river may almost disappear from view, seeping slowly through its shifting sands. A well-known example is the Platte River, whose channel is so choked with sand that it is barely able to maintain its flow at all. As meandering is impossible where downward cutting is very rapid, so also is it impossible in an overloaded stream like the Platte, since it has no energy left with which to attack even the softest bank. It would seem, then, that meandering belongs to a middle stage, where the load is so adjusted that the river is alternately cutting and filling up its valley.

In a process with so many complicating factors as river action,

* It must be remembered, of course, that a stream uses the matter carried as the tool with which the deepening is done and with no waste at all a stream would be all but powerless to abrade its bed.

one is naturally rather hesitant about accepting *à priori* arguments unsubstantiated by other data. It was, therefore, highly desirable to submit this conclusion to experiment and to test its validity. Fortunately, as is well known, the dynamics of river action may be observed in any wayside streamlet after a rain. Accordingly, an effort was made to bring such a streamlet under experiment where the conditions could be controlled. The stream selected was one flowing down a steep grade, so that the current was quite swift. Before it was disturbed it was nearly straight, as such streams usually are. To expedite the experiment, it was turned from its course and made to follow a set of meanders constructed for it. In these prepared meanders each was approximately a semi-circle, and all were of about the same radius, so that the stream, except for accidental variation, due to differences in the number of larger pebbles in its bed, had nearly uniform conditions throughout the portion under experiment. To keep accurate record of the initial position, small sticks were driven into the banks in pairs, one on each side of the current. From a point near the middle of the set of meanders, sand was dumped into the current as fast as it could carry it away, so that one half of the course was heavily loaded, the other lightly. The amount of sand supplied was so great that it could be carried but a few inches before it was dropped, forming miniature sand-bars. These were built out from the lower side of each meander, so as to move the projecting point of the convex bank down stream. This narrowed the channel and forced the water against the opposite bank, which began to crumble and wear away. After about fifteen minutes of this treatment the meanders were appreciably more crooked. In some cases the change was so considerable that all of the swift portion of the current had moved over outside that of the peg originally set at its convex edge, which now stood, therefore, at the concave edge. But in the upper half of the course laid out no change was apparent in the same time. To check the result further the upper half of the course was then overloaded as had been the lower. The response was immediate and identical to that of the lower half. This would seem to show beyond a doubt that a swift stream can be made to meander simply by giving it a heavy load to carry.

But a stream can never build up a bar above its own level, or even quite up to that level, so that in the experiment, though the whole current was deflected against the farther bank as described, there was always a slight amount of water covering the top of the bar. In the streamlets experimented with, which were of nearly constant

volume, a point was reached if the experiment was carried far enough, where the retardation of the current, by its increasingly crooked course and the slight difference in level between the upper and lower sides of the bar built out, gave sufficient head to the shallow water moving across it to enable it to pick up the recently-deposited sand and cut a new channel through it before the meander had been worked out to nearly so great a departure from the original course as is usual in a large river. The cause of the difference is easy to see. In the river the bars are built up above the normal level at every slight rise, thus cutting off the flow across the meander before there is danger of the head across it equalling the force which deflects the water into the longer course. Thus we see that, for the maintenance of a meandering course, variations in the level of a stream are of considerable importance. It is a matter of common experience that meandering streams are usually subject to variations in volume from time to time. The growth of plants is very important in this connection; for in the river the bars are almost at once occupied by plants which by their roots compact and bind together the loose material and by their tops catch more at the next rise, so at once helping to hold the material already deposited and to catch more.

Besides these experiments observations were made upon streamlets lightly loaded with detritus. In such streams, though the force of the current was probably strongest on the outside banks of the bends as assumed in the common explanation of meanders given above, there was still some force left to abrade the inside bank, causing a wearing away of the projecting point on the inside, which, if continued, soon furnishes the stream with a shorter course at a higher grade. This new channel diverts more and more of the current, so that in a little while the stream has abandoned its meander and is following the straighter course. Thus a stream is enabled to straighten its course if it be not so heavily loaded that it must deposit débris with small checks to the current. And we begin to see how it is that swift streams, being usually lightly laden, are "less easily turned aside and maintain straighter courses" than those which, by reason of their smaller velocities and soft valley bottoms, are apt to be heavily loaded. As noted above, the Buffalo, in portions of its lower course, is cutting both of its banks; and while the cut on the inside bank seems not to be sufficient in this case to result in straightening the stream, it certainly must retard its lateral wandering and tend to keep it in its bed.

Deposition on the slackwater sides of obstructions in the current

of a river assumes, then, a very considerable importance. Its function is threefold: (1) As shown above, it is a controlling factor in the downward-cutting power of a stream; (2) by building out bars behind obstructions it prevents the stream from removing the obstructions and straightening its course; (3) these bars narrow the channel and force the water yet more strongly against the opposite concave bank, causing it to be worn away more rapidly.

Returning to the Buffalo River, we are in a better position to understand the anomaly it presents of a swift stream rapidly meandering. As described above, its banks are composed exclusively of sand and gravel, so loosely compacted that they offer even less resistance to the wearing of the water than the alluvium of most flood-plains, and as soon as it is touched by a current of the requisite velocity it is whirled away. The stream is thus enabled to pick up on the outside of every bend almost as much as it can carry. A part of this load it is compelled to drop only a few rods below in the slackwater at the next convex bank. The nature of the material is especially favourable to sudden deposition; for the sand and pebbles which make its bank are so coarse that they settle rapidly, affording strong contrast in this respect to fine silt, which requires some minutes to settle even in perfectly still water. The importance of this is manifest, if it be remembered that the slackwater spaces of a small stream are very short, so that such fine silt, even though it might have time to settle in the mile-long slacks of a great Mississippi, would in the Buffalo, before it had reached the bottom, have moved into another riffle, and so its final deposition would be rendered very uncertain. Thus we understand how our stream goes on continually eating out its meanders and building up its flood-plain at a rate incredible to a student familiar only with such sluggish meandering rivers as the Mississippi.

Summarising our results, we may state—partially, at least—the factors controlling the meandering of streams. Meandering is independent of velocity. It is possible only when the stream is so heavily loaded with waste that it begins to precipitate its load with comparatively slight checks to its velocity. A stream, to meander, must be subject to variations in volume. The direct causes of meandering are two: First, the tendency of a loaded stream to deposit sediment behind any obstacle projecting into the current. Such deposits have a double effect: They protect the obstruction from wear and prevent the stream from gradually removing it and straightening its course; and they aid the obstruction in deflecting the current against the opposite bank. The second cause of meandering is the lateral cutting of a current of water, flowing in a crooked channel, on the

outside of the bends which confine its course. This is brought about by the centrifugal force of the moving water. These two causes are complementary; each aiding the other, and together giving rise to the remarkable shifting in the channels of such streams as the Buffalo River.

THE BRITISH NATIONAL ANTARCTIC EXPEDITION.

BY

PROF. ANGELO HEILPRIN.

The narrative of the British National Antarctic Expedition of 1901–4, which has latterly been given to the world in two sumptuous volumes entitled "The Voyage of the Discovery,"* establishes for that expedition a just claim to being considered one of the most successful of all Polar ventures. No earlier voyage of discovery into the icy seas, whether in the north or in the south, has more distinctively accomplished its mission than this one; and none has treated more attractively and satisfyingly of the deeds of its explorers, or given in more graphic form the picture of a long-protracted struggle with nature and of the courage and self-denial which sustained this struggle.

Captain Robert Falcon Scott, R. N., the commander of the expedition, has easily earned the distinctions which have been conferred upon him, for he has not only established a far-reaching Antarctic record in his penetration (on Dec. 30, 1902) to lat. 82° 17′ S.—an advance of nearly 250 miles on his predecessors—but in minor explorations he did much that, wholly apart from the major explorations, would have given a more than reputable standing to the ordinary aspirant for fame. Of such explorations may be cited the survey of the great Ross Barrier to the point of its disappearance in the easterly King Edward VII. Land and the traverse of the lofty snow and ice plateau which, in South Victoria, extends westward from the Admiralty and Prince Albert Mountains, and rises in its bleak and desolate form, the counterpart of the great ice-cap of Greenland, to elevations of 8,000–9,000 feet or more.

Naturally, the chief interest in the narrative centres about the long southern journey and the traverse of the great Antarctic Barrier which bounds the Ross Sea on the south in about lat. 78° S., and so effectually barred the progress of James Clark Ross sixty years earlier. This vast mass of ice, which extends in an

* Charles Scribner's Sons, 1905.

east and west direction for the better part of 350 miles, and which has been assumed by most geologists to represent the terminal or lateral margin of a vast continental glacier, rising in the interior to heights conjectured by some to be 25,000–30,000 feet, is now determined to be an almost perfectly flat expanse of shore-ice or frozen sea-surface—so flat as to make no perceptible rise for the full distance over which it was observed. It was over this ice, following closely the meridional trend of the lofty and clearly-defined mountain ranges of an unmistakable united land-surface (Victoria Land or South Victoria), that the long journey southward was effected. Captain Scott, with much to support his view, believes this flat ice-sheet—which is thought to rest freely on the ocean, and whose front edge (disclosing fairly deep water) has retreated upwards of twenty miles since its existence was made known by Ross—to represent the true contact of the (continental) land and oceanic areas, and with some plausibility argues that this contact-line may extend completely across the polar regions and be followed almost meridionally to Graham Land, to the far south of the extremity of the South American continent. The position and continuousness of the vast mountain ranges, with numerous summits rising above 8,000–10,000 feet, and with a few (Markham, in lat. 83°; Lister, etc.), attaining 13,000–15,000 feet, and extending unbroken to the farthest point of vision (as observed from lat. 82° 17′), would certainly seem to sustain this view, even if the conditions cannot be held to prove it absolutely.

The "farthest south" of the British expedition, despite the seemingly favourable conditions for its accomplishment that were to be found in the low-lying terrain and a genial and not too high temperature, was attained only after extreme toil and hardship, and through a process which taxed to the utmost the resource and indomitable energy of the commander. No finer exhibition of morale is to be found in the annals of exploration than is disclosed in the narrative of this struggle for the attainment of the unknown, but the cool student of exploration will recognize that just in this struggle is revealed the one weak point of the expedition, and where comparison will fail to sustain for it equality with similar work accomplished elsewhere. The incapacitation of the dog-teams almost with the day of the starting, the breaking in of incipient scurvy, and the reduction of the leader of the party to that degree of mental and physical strain which in the later stages of the journey precluded all interest in the enterprise beyond what touched the cares of the day and the hopes for the morrow, were not the lesson that should have been learned from Mr. Peary's

brilliant traverses of the inland ice of Greenland. The geographer cannot but deplore the lack of earnest study in the preparation of the details for this phase of the British exploration, for it cannot be doubted that with a sustained dog-team and the proper adjustment of travelling impedimenta a much farther point south would have been attained than that officially recorded and with a much less expenditure of bodily force. The distance travelled on this journey, going and returning, was approximately 750 miles, accomplished in 93 days, or within almost precisely the same period of time in which Mr. Peary accomplished his memorable "white journey," over an incomparably longer course (although comprised within almost exactly the same degree of latitude N.), in 1892. Somewhat more expeditious was the journey over the westerly ice-plateau in the latter part of 1903, when a distance of 300 miles from the ship's quarters, in lat. 77° 59′ S., long. 146° 33′ E., was covered in 34 days, and with a return in 25 days.

Captain Scott corrects numerous misconceptions which prevail regarding the conditions existing in the Antarctic tract. Probably the most interesting, and certainly the most surprising, of these is that which pertains to the accessibility of the region. Since the early explorations of Wilkes and Ross almost to the present day it has been generally assumed that Antarctica was so closely bound in with ice as to render penetration to it a matter of extreme hazard, and expeditions in search of the unknown in that quarter have been looked upon as hardly more than ventures. Even the more or less successful voyages in recent years of Larsen, Borchgrevink, Gerlache, Drygalski, and Nordenskjöld have not prepared us for the statement (although the counterpart of the condition had already been known to exist in Melville Bay, off the N.W. of Greenland) that during any average February "a ship, by coming directly south on the 178th meridian, could reach the Great Barrier without encountering any pack-ice." And further (Vol. II, p. 407): "It is strange to think that there may be a season in the year when the enterprising tourist steamer may show its passengers the lofty smoke-capped form of Mount Erebus as easily as it now does the fine scenery of Spitzbergen."

Geographers will learn with interest that their notions regarding the size of the Antarctic bergs are not wholly accurate. Apparently there are few bergs which exceed a mile and a quarter or a mile and a half in length, or that exceed 200–250 feet in height—a measure which brings them close within the dimensions of the larger tabular bergs of Melville Bay and the North Water off Greenland. In the region explored by the officers of the *Dis-*

covery there would seem to be no individually-differentiated glaciers of the size of the largest of northwest Greenland. A period of recession has been existing for some time, and the morainic material that hangs to the upper mountain slopes shows in some instances a diminution in the thickness of the glacial ice, as compared with a former period, of 2,000–3,000 feet or more. Captain Scott finds no facts to support the conclusion that the recession of the ice-sheets is due to progressive moderation of the climate, or to the incoming of a warm period. The evidence seems clearly to prove that the present period is an extremely cold one—too cold to permit of sufficient precipitation to form glaciers of the larger dimensions which characterized the earlier periods of higher temperature. Numerous facts to support the conclusion that certain glacial periods might be the result of elevated rather than of depressed temperatures might easily be drawn from other regions of the earth's surface, and perhaps most appealingly from Grant and Grinnell Lands in Arctica, where much of the mountain tracts rising to or above 3,000–4,000 feet (Arthur and Garfield Ranges) is, even on the 82nd parallel of latitude, destitute of a snow-covering.

On the home journey, in the spring of 1904, the *Discovery* sailed westward S. W. of the Balleny Islands, on a course that traversed what on some maps appears as the most easterly part of Wilkes Land. No land was here sighted, not even at the point, in long. 154° E., where Cape Hudson should have appeared as a conspicuous landmark. This negative determination can, however, hardly affect the question of the more broadly-determined facts which pertain to the assumed land-masses lying farther westward which were described and pictured by Wilkes. It is earnestly to be wished that some country desirous to add to the fame of its flag, or a generous patron of discovery, may before long despatch an expedition equipped for service along the line that was traversed by Wilkes and for the survey of that still largely unknown area which is comprised between the meridians of 90° and 150° of east longitude.

No very important light is thrown upon the geological construction of the Antarctic regions through the researches of the British National Antarctic Expedition, despite much attention that was paid to geological details. The heavy covering of snow and ice precludes extensive study or examination of rock-masses, and, unfortunately, in the region under examination no determinable fossils were obtained. In this relation, therefore, the region seemingly offers much less than Graham Land and the adjacent island (Seymour Island) and islets, where Larsen and Nordenskjöld ob-

tained the remains of araucarian forests, besides a fair abundance of Jurassic, Cretaceous, and Tertiary (?) molluscan forms—all helping to establish a biologic connection, whether on the land or in the sea, between the faunas of the far south and those of the region lying north of Lat. 55° S.

Space does not permit of more than a reference to the special scientific work of the expedition, which will doubtless be detailed in future monographs by those most competent to treat of the different subjects. Of particular interest among the geological studies are those pertaining to the life histories of the different species of seal and of the emperor penguin. One cannot properly pass over this section of the work without referring to the extraordinary habit which is recorded of one or more species of seal of dragging their bodies, at about the time of impending death, to distances on the inland ice of fifty miles or more and to elevations of 5,000 feet. The geologist and physical geographer can well appreciate at this time what destructive evidence bearing upon land elevations or oceanic transgressions might be obtained from the remains of these sea-animals that are now found so far removed from their natural habitats. In its present climatic aspects Victoria Land may not improperly be compared with the far north of Greenland or with the opposite Ellesmere, Grinnell, and Grant Lands. A mild and genial summer temperature—less mild, however, than in the Arctic tracts—alternates with a winter of extreme severity, and contrasts with the monotonous cold that in more or less continuousness was noted by Nordenskjöld in the region of Graham Land. The lowest official recorded temperature made during the traverse of the lofty plateau was — 72°.

The illustrations which accompany Captain Scott's work do full justice to the text, and in themselves would give exceptional value to the report. Few works of travel and discovery have had such support given to them from the camera and photographic process.

GEOGRAPHICAL RECORD.

AFRICA.

THE NILE-RED SEA RAILROAD.—The new railroad across the Nubian Desert, between the Nile and the Red Sea, was opened for business February 17. The line is 331 miles long, and it has cost about $8,000,000. Construction began at the Red Sea in August, 1903, and the first train passed over the road in October, 1905, the entire work, therefore, occupying only a little over two years. The Red Sea terminus is Port Sudan, 30 miles north of Suakin, to which as a harbour it is much superior.

During the past year many houses have been erected for the whites, the railroad station and lighthouse have been built, and 4,000 labourers have been making port improvements; and the working force will be increased to 6,000 this summer.

The Nile terminus of the road is at the mouth of the Atbara River, a short distance south of Berber, where trains will be switched to the Wadi Halfa-Khartum railroad for their destination—Khartum or Berber. As the country traversed is almost completely desert, it can supply little or no commerce, and the purpose of the road is to cheapen freights between the Anglo-Egyptian Sudan and the outside world by supplying a short route to the sea.

Survey of the Moroccan Coast.—Some time ago the French Committee of Morocco appealed to the public to contribute to the work of pacific penetration in Morocco which Mr. Delcassé had undertaken. Mme. Hériot thereupon offered a substantial sum of money for the much-needed survey of the Atlantic coast of Morocco. The only naval chart of that shore now in use dates from 1835, and is full of errors. Lieut. Dyé and Mr. Renaud were selected to study the outlines of the coast from Tangier to Agadir. The work was carried out last year, and Lieut. Dyé's report is printed in the *Bulletin* of the Comité de l'Afrique Française. This coast in winter has long been the terror of navigators, and the conclusions which the surveyors have reached do not lessen its bad reputation. The report explodes the idea that there is a good natural port at Agadir in the Sus region. There is, in fact, no natural port in Morocco on the Atlantic coast. Many valuable suggestions as to navigation in those waters—the construction of lighthouses, etc.—are given.

Meteorology at the British Association in South Africa, 1905.—In the October and November numbers of *Symons's Meteorological Magazine*, Dr. H. R. Mill gives an account of the meteorological and climatological matters of interest in connection with the South African meeting of the British Association. On the voyage to the Cape a lecture was given by Professor W. M. Davis "in 1° N., on August 7th," on the Weather of the Atlantic, and another, by Dr. Mill, "in 15° S., on August 10th," on the Bed of the Sea and the Circulation of its Waters. At a meeting of the General Committee at Cape Town on August 15 an important resolution was adopted regarding the co-ordination of the meteorological services of the British Empire. The object of each department of the service would be the collection and summarizing of observations taken in different parts of the Empire, and the providing of

> a scientific staff for dealing with the more general meteorological problems, including their relation to Solar Physics and Terrestrial Magnetism, which involve the co-ordination of data from wide areas, and to promote experimental investigations of the scientific questions which arise in connection with such discoveries.

A truly epoch-making resolution!

Several papers of meteorological interest were read, but were scattered through different sections, which interfered with their discussion by those most directly concerned. A Meteorological Breakfast, which has become a feature of the British Association meetings in England of late years, was held at Cape Town on August 18th. At Johannesburg further sectional meetings were held, and more papers were read. The new observatory of the Transvaal Meteorological Service was thrown open by the Director, Mr. R. T. A. Inness, who showed the admirable equipment of self-registering and other instruments. The journey into the interior afforded opportunity for further study of local meteorology and climate. The full effects of the dry season were noted in the bare, dry veld, "covered with burnt-up grass and low shrubs, but only wanting irrigation to become extremely fertile." Fine displays

of sheet lightning were seen on the high veld, but there was no thunder or rain. In the intensely dry weather the hair crackled with electricity when being brushed.

At Kimberley the observatory of Mr. J. R. Sutton was visited. This observatory was partly equipped by the De Beers Company, but all the observations are taken by Mr. and Mrs. Sutton. Mr. Sutton's work at Kimberley has already received notice in this BULLETIN. Going north from Kimberley, the grass on the dry veld gradually gave place to low, thorny shrubs and next to thin forest, the green leaves breaking out afresh in advance of the rains. It being the end of the dry season, the water in the Zambesi was at its lowest, and therefore the scenery of the rock gorges at the Victoria Falls could be well seen. At Buluwayo, on September 14th, the shade temperature was 85° and the wet-bulb 55°, showing a relative humidity, according to the tables, of only 9%! As Professor C. V. Boys said in a lecture at Cape Town, in the interior of South Africa water evaporates as rapidly as does alcohol in damper climates. R. DEC. W.

AFRICAN CLIMATOLOGY.—Meteorological observations from portions of Africa but recently redeemed from savagery are accumulating rapidly. Among the publications which deal with African climatology the *Deutsche Ueberseeische Meteorologische Beobachtungen* are of great value. These volumes are issued by the German Naval Observatory (Deutsche Seewarte) at Hamburg, with the co-operation of the Colonial Division of the Foreign Office. Volume XIII, a quarto of 317 pages, is a continuation of Vols. X and XI, and deals with observations from German East Africa. The hourly readings of barographs, thermographs, anemographs, hygrographs, and sunshine recorders are given for stations where these instruments are in operation. There are also complete eye observations of the ordinary elements, made three times daily at 22 stations. Details regarding the location and exposure of the different stations, as well as the corrections for the local readings, are given in each case. The hours of observation differ; in most places they are 7 A.M., 2 P.M, and 9 P.M., but in individual cases they are 8 A.M., 10 A.M., and 4 P.M. (TANGA); 7 A.M., 2 P.M., and 8 P.M. (KWAI); 6 A.M., 1 P.M., and 6 P.M. (NEU-KÖLN), and various (KILOSSA). This is an extremely valuable collection of data when the locality in question and the completeness of the observations are considered. R. DEC. W.

AMERICA.

COAL RESOURCES OF WYOMING.—The School of Mines of the University of Wyoming publishes as *Bulletin* 7 a report on the coal resources of the State by Professor L. W. Trumbull. In 1869, 58,186 tons were mined; while the production in 1905 is estimated at 5,500,000 tons. The various estimates of the area of the Wyoming coal measures at from 20,000 to 40,000 square miles are probably under the truth, though undoubtedly much of the coal is so deeply covered that it will not be dug for many ages. All the coal is found in rocks of the Cretaceous, this formation being to Wyoming what the Carboniferous is to Pennsylvania. The report contains a sketch map showing the wide distribution of the Cretaceous, and also of Cretaceous covered by Tertiary.

THE ILLINOIS STATE GEOLOGICAL SURVEY.—The Illinois State Geological Commission was organized last August by the appointment of Prof. T. C. Chamberlin, of Chicago University, to serve with the *ex-officio* members, Governor C. S. Deneen and President Edmund J. James of the State University. Dr. H. Foster Bain was appointed Director of the State Survey in September, and took up his work in November last. The Board had already arranged for topographic work in the season

of 1905, and the results have been announced in the *Bulletin*. The work planned for 1906 includes the completion of the survey of the Wheaton and Aveston quadrangles, which were partly surveyed in 1905, with the survey of the Galena, Waukegan, and Farmington quadrangles. In addition, a line of precise levels is to be carried from Chicago to Odin, one-half the work being done in 1906 and one-half the following season. In a line of precise levels, run last year, 84 miles long, the actual error was found to be less than a quarter of an inch; and in certain primary traverse lines, 60 miles long, run around one of the quadrangles, the circuit came within 20 feet of longitude and ten feet of latitude closing. The work is being done with unusual care, level lines being run along all of the roads, up many of the streams, and well out into the sections between the roads. In 1905, 365 geodetic stations were occupied, and more than 3,500 miles of spirit-levels run. It is believed that the maps, when completed, will be quite as good as any that have yet been made. It is found that in Illinois, owing to the general flatness of the country and the large number of straight roads, it is possible to make accurate surveys with unusual economy.

The geologic work proper is now being organized. In general it will be mainly directed to a study of the coal and clay resources of the State. The work on the latter has already been begun. Mr. Ross C. Purdy, late of the Ohio State University, and now Instructor in Ceramics at the State University of Illinois, under the direction of Professor C. W. Rolfe, is making a complete study of the paving-brick industry and the paving brick clays of the State. This is to be followed by a study of the pottery industry. Mr. Purdy took up field work in November, and material is being collected for a careful series of laboratory investigations running through the winter months.

Pine Seeds Distributed by Prevailing Winds.—In a recent report on the *Loblolly Pine in Eastern Texas* (U. S. Department of Agriculture, Forest Service, Bulletin No. 64, 1905), by Raphael Zon, reference is made to the distribution of the seeds of this pine by the winds. On the wet prairie of Eastern Texas islands of these trees are very characteristic, occurring on slightly-elevated mounds. In the early stages of development these islands are often almost circular, with the older trees in the centre and the younger ones towards the margins. Loblolly pine seeds ripen at the end of September and early in October. At this season dry northwesterly winds prevail. These winds hasten the opening of the cones and carry the seeds towards the southeast. R. DeC. W.

The New Jersey Geological Survey.—This Survey is revising and issuing new editions of its topographical atlas on a scale of one inch to a mile. Last year four new sheets replaced an equal number of older sheets now out of print. It is also preparing and publishing from time to time topographical sheets on a scale of 2,000 feet to an inch. In 1905 three sheets were issued and surveys were completed for three more. There will soon be twenty-four sheets on this scale.

Studies were made of the Upper Passaic Valley in elaboration of the proposed plans for controlling floods upon that river by a dam at Little Falls and for the establishment of a permanent lake and reservoir. Investigations were also made of the wasting of the beaches and the shifting of bars and channels at the inlets and the best methods of controlling these movements.

The peat, sand, limestone, and building stones of New Jersey were the subject last year of special investigation, both in the field and laboratory, and reports are being prepared upon the peat and limestones. The sands and building stones are still under investigation.

Studies are in progress regarding the trap rock and associated copper deposits, with a view of determining the source of the copper and its mode of accumulation.

Paleontological studies have been pursued on the fauna and flora of the Cretaceous formations, and reports are being prepared for publication.

GLACIAL PHENOMENA ALONG THE NORTH SHORE OF LAKES HURON AND MICHIGAN.—The last Annual Report of the Michigan Geological Survey (Report for 1904) contains a paper by Prof. I. C. Russell, in which the glacial phenomena of a part of northern Michigan are described and discussed (pp. 57–94). There is a consideration of the evidences of ice erosion, including a discussion of certain interesting features relating to striæ and the bearing of these on the subject of ice erosion on a large scale in this region. Regarding Lakes Huron and Michigan, Russell is of the opinion that the glaciers did more toward filling pre existing basins than of deepening them. His paper discusses various drift forms and the shore-lines and clays of the ancient ice-dammed lakes. Perhaps the most notable section of the paper is that on drumlins, of which there are two areas in the region covered by his work—one the Les Cheneaux area, the other the Menominee area, in approximately the same latitude, but 125 to 150 miles apart. In addition to a description of the characteristics of the drumlins of these areas, in which they form the dominant topographic forms, Russell discusses their origin, and concludes that the drumlins of the Menominee region have resulted from the erosion of a previously-deposited till sheet. This is a revival of Prof. Shaler's theory, which a majority of glacial geologists have discarded in favour of the theory of formation by sub-glacial deposit. R. S. T.

GLACIAL STUDIES IN THE CANADIAN ROCKIES AND SELKIRKS.—A paper under this title by Dr. W. H. Sherzer (Smithsonian Miscellaneous Collection, Vol. II, Part 4, pp. 453–496) describes in detail the phenomena illustrated by a number of the glaciers of Alberta and British Columbia. The physical features of the ice, the banding of the ice, the moraines, the rate of ice motion, and the frontal changes are all discussed upon the basis of observations upon several glaciers. One of the most noteworthy points brought out by this paper is the clear evidence of a shearing along planes between adjacent ice strata. This paper, which is illustrated by a large number of excellent half-tones, is an important contribution to glacial geology, both from the standpoint of its local details and of its discussion of general principles of ice characteristics and behaviour. R. S. T.

MODELS OF MARTINIQUE AND MT. PELÉ.—The American Museum of Natural History in this city is now exhibiting a series of models illustrating the island of Martinique and the effects of the eruptions of Mont Pelé. There are four models, one of which is the whole island upon a scale of 1:80,000, modelled from the French Admiralty Chart, and three enlarged models of the volcano itself upon a scale of 1:24,000, or 2,000 feet to an inch. In all the models the vertical scale is the same as the horizontal. The first of the large-scale models shows the volcano as it was at the first great eruption on May 8, 1902, when the city of St. Pierre was destroyed. The second shows the changes in the volcano in the succeeding months, including the destruction wrought by the eruption of Aug. 30, 1902; and the third shows the wonderful spine and cone of lava pushed out of the conduit and crater during the winter and spring of 1902–3, the time selected being the period of maximum development.

RAILROADS IN GUATEMALA.—Mr. Charles M. Pepper, in his monograph on "Guatemala" (Washington, 1906), says that the Northern Railroad will be open for traffic by the end of 1906. The line extends from Guatemala City to El Rancho and thence to Puerto Barrios. This will place the capital and the whole interior of the country in direct communication with Puerto Barrios and insure a large reduction in the cost of freight. It will also open up a very rich region which now has only the

most primitive means of communication. On the Pacific slope the leading railroad system is the Guatemala Central. Its main line and branches cover the coffee-raising districts of the Pacific Coast. In addition to its railroads, Guatemala has recently built, or is now constructing, a system of nine highways or cart roads extending through various parts of the country.

AUSTRALASIA.

GLACIAL EROSION IN NEW ZEALAND.—Recent literature has furnished descriptions of conditions in Alaska, Norway, Switzerland, and other regions which point strongly to the conclusion that glacial erosion has profoundly modified the valleys of these regions, and given rise to some of their characteristic topographic features. Southwestern New Zealand resembles Norway and Alaska in mountain form, fjorded coast, and former great extension of glaciers; and it is interesting, therefore, to note that the topographic features which have caused the belief in marked erosion in Norway and Alaska are found in great perfection also in New Zealand. A recent paper by E. C. Andrews (Trans. Australasian Assoc. Adv. Sci., Jan., 1904, pp. 189–205) describes and interprets these features and illustrates them with a series of excellent half-tones.

Going to New Zealand from eastern Australia, Mr. Andrews was impressed by the absolute difference in the topography of the two regions, although both were in approximately the same stage of topographic development. In eastern Australia the tributary valleys enter the main streams at grade, and the valleys possess a series of overlapping spurs; but in southwestern New Zealand the tributary valleys join the main valleys at discordant levels, in some cases 2,000 feet above the valley bottom, and the valley wall spurs are truncated—in some cases entirely removed, in others partly destroyed. These two results, and some other features of the region, Andrews assigns to glacial erosion, agreeing with the interpretations of Gannett, Davis, Gilbert, Penck, and others for European and American regions. Andrews' paper is an important contribution to the subject of glacial erosion, adding one more glaciated district which possesses topographic features that so far have not been recognized in perfection in non-glaciated regions. R. S. T.

DROUGHT OF 1901–1902 IN NEW SOUTH WALES.—*The Results of Rain, River, and Evaporation Observations made in New South Wales during 1901–1902*, under the direction of H. C. Russell, Government Astronomer, recently received (date of publication 1904), give some startling facts regarding the drought of these years. Although now somewhat out of date, this volume gives the first authentic information, coming through the official meteorological channels of the New South Wales Government, which has been sent us as to the conditions of this unprecedented drought. Taking the rainfall of 1902 for the whole State, the amount is the smallest on record except that for 1888. The year 1902 had an average of 14.09 inches, while 1888 had 13.40 inches; but 1888 was preceded by a series of years of plentiful rainfall, and 1902 was the eighth consecutive year of drought. The results were most disastrous, especially in the western country. Here sand and dust storms, due to persistent dry winds, were a dominant feature. Drifting sands were carried over the plains until stopped by fences, where they were banked up and formed dunes. Stock-yards, wool-sheds, gardens and fences were buried; dams were filled up, and their embankments destroyed.

During the seven years ending with 1901 the number of sheep grazing in the Western Division fell from 16,000,000 to about 5,000,000, the total loss being fixed at at least 30,000,000 pounds sterling. The effect of the drought was shown in a

peculiar way—in the decrease in the number of voluntary meteorological observers. There had previously been a steady increase up to 1719 in 1901, but the number fell to 1650 in 1902 as the result of the temporary abandonment of their homesteads by the farmers. Much the same thing, it may be noted, happened in South Africa during the recent drought there. R. DEC. W.

EUROPE.

THE BASIN OF THE MOSELLE.—No. VII of "Ergebnisse der Untersuchung der Hochwasserverhältnisse im Deutschen Rheingebiet" is devoted to the basin of the Moselle, including those parts of it outside the German territory. The Moselle is the most important tributary of the Rhine on the left, and this official report, prepared in the Meteorological and Hydrographical Bureau of Baden, and published by Wilhelm Ernst & Son, Berlin, is practically exhaustive and a fine example of the thoroug discussion of the various physical aspects of a river. The quarto volume is richly equipped with superior maps in colours, among which are sheets showing the topography and geology of the basin, its forestation, and the distribution of its rainfall.

THE FOREST-LINE IN THE AUSTRIAN ALPS.—Professor R. Marek has a preliminary report in the *Mittheilungen* of the Vienna Geographical Society on his studies of the altitude of the forest-line in the Austrian Alps. He finds that this line sinks continuously from west to east, the rate of fall increasing towards the east, and a difference of 556 meters being recorded in an area that extends through about five degrees of longitude. The average height of the forest-line is about 750 meters below that of the snow-line.

BALLOON VOYAGE ACROSS THE ENGLISH CHANNEL.—Messrs. C. F. Pollock and Martin Dale, members of the Aero Club, made a successful balloon voyage from England to France on Feb. 3. They passed out to sea at Eastbourne at 2 P. M., and, after a speedy crossing of the Channel, descended between Havre and Dieppe in three hours twenty minutes after the start. The distance travelled was 140 miles. The balloon was inflated with 50,000 cubic feet of gas.

POLAR.

BARON VON RICHTHOFEN'S LAST WORK.—The house of Dietrich Reimer, Berlin, has just printed, at the special request of Emperor William, the incomplete report of the "Ergebnisse und Ziele der Südpolarforschung," which von Richthofen had begun to prepare for the Emperor shortly before death ended his labours. The famous geographer gives a survey of the problems to be solved by the South Polar expeditions, and describes particularly the services of the German expedition under von Drygalski, a pupil of von Richthofen, in the investigation of the fauna and flora of the regions explored. This is the extent to which von Richthofen had completed the work.

BAFFIN ISLAND NOT TO BE RE-EXPLORED AT PRESENT.—Concerning the recent report that Canada proposed to re-explore Baffin Island and its great inland lakes, Mr. James White, Geographer for the Department of the Interior, writes that the Government does not at present intend to undertake this work. It is, in fact, doubtful that the work will be undertaken in the near future, in view of the enormous extent of the Canadian territory, more accessible and of much greater importance, that still remains to be studied in detail.

THE SCIENTIFIC STATION ON DISCO ISLAND.—We have received a letter from Dr. Morten P. Porsild announcing that the proposed permanent station for the study

of Arctic science on Disco Island, in Danish West Greenland, will be established under his direction this summer. The cost of founding the station has been met by Mr. A. Holck of Copenhagen, and the Danish Government has granted the sum of $3,000 annually for its maintenance. The station will be especially equipped for biological researches, and conveniences for work will be supplied for visiting naturalists, both foreign and Danish. Visitors can first be received in 1907, and notices inviting applications will be sent out in due time. It is expected to establish at least two out-stations where investigations may be carried on as well as at the central laboratory. Visitors will have free use of the instruments, travelling outfit, and library; lodging will be free, and a small charge will be made only for board. Dr. Porsild will be glad to receive gifts of publications relating to the Arctic regions, and especially to Arctic biology. It is desired to make the library as complete as possible; but as the resources of the station are limited, only a small part of the books can be purchased.

VARIOUS.

A Periodical Devoted to Earthquakes.—The Magazine *Die Erdbebenwarte*, edited by Professor A. Belar and published at Laibach, is now in its fifth year. Among the contents of the latest issue (Vol. V, Nos. 1–4) are articles on the Seismic Observatory in Munich; Earthquakes in Servia in 1904 (125 distinguishable without the seismograph, and many earth tremors); Premonitions of a volcanic eruption by means of a seismograph (the outbreak on Savaii as indicated at the Samoa Observatory, Apia); Vicentini's new seismograph; monthly earthquake reports, book reviews, notes and news, etc. It is a publication of great value to the student of earthquake phenomena.

Vesuvius in Eruption.—Mount Vesuvius was very active early in February. The lava reached three places on the Vesuvian railroad line, covering about 100 yards of it at each point.

Distribution of Earthquakes.—The relations of the structure of the earth's crusts to earthquakes are discussed in the January number of the *Annales de Géographie*. "Observations of more than 170,000 earthquakes show that they occur almost equally and exclusively along two narrow zones lying on two great circles of the terrestrial sphere; the Mediterranean or Alpine–Caucasian–Himalayan circle, with 53 per cent. of recorded earthquakes, and the circum-Pacific or Andeo–Japanese–Malaysian circle, with 41 per cent." These observations, it is asserted, give no support to the theory that the tetrahedral distortion of the earth's crust is due to this cause.

The Kangra Earthquake.—Thirty-six pages of the *Records* of the Geological Survey of India (Vol. XXXII, Part 4, 1905) are given to a preliminary account of the Kangra earthquake of April 4 last year. The report is written by C. S. Middlemiss, one of the three superintendents of the Geological Survey. The starting-point of the earthquake was the Kangra district of the Northwestern Himalayas. About 20,000 persons are estimated to have perished, the loss of life being greatly increased by the fact that the most violent phases of the shocks occurred early in the morning, when many were still asleep. The earthquake was appreciable to the senses over an area of about 1,625,000 square miles, or a territory more than half as large as the United States. The shocks were brief and of powerful intensity. At Dharmsala it was impossible for a person to keep his feet while standing or walking. It has not been possible to decide as to the depth of the centrum, where the disturbance originated. The rate of movement of the earth-waves appears to have been 1.9 miles

per second, or considerably less than the rate in the Charleston earthquake, which was about 17,000 feet per second. The conditions among the mountains were ideal for the production of land-slides on a gigantic scale. Two maps show the outer boundary of the shaken area, the four highest isoseismals and the approximate positions of the axial epicentrums.

THE INTERNATIONAL GEOLOGICAL CONGRESS IN MEXICO.—The General Secretary of this Congress has distributed the programme of the excursions to be held in connection with the meeting of the Congress in the City of Mexico during next September. Four excursions are provided before the opening of the Congress. The first, lasting four days and confined to 250 persons, is to be to the east from Mexico City through Jalapa to Vera Cruz, returning to Mexico through Esperanza; the second, to the south, will be eight days and limited to forty persons, the party going to Esperanza, Tehuacan, and Oaxaca; the third, limited to thirty members, will include visits to the volcanoes of Toluca, San Andres, and Jorullo, and will last fourteen days, nine of which will be on horseback; the fourth is to be to the geyser district of Ixtlan and to the volcano Colima. During the meeting of the Congress short journeys will be made to various places near the capital, and at the close of the sessions an excursion to the north of twenty days and another to the Isthmus of Tehuantepec will take place.

COST OF MOUNTAIN-CLIMBING.—In Switzerland a tariff is established by the Government, which declares what the fee shall be for the climbing of any of the principal peaks. The fee is regulated by the time consumed and the difficulties presented in making a given ascent. The Matterhorn will cost the climber 200 marks ($40); Mont Blanc probably as much; the Eiger and Mönch in the neighbourhood of 125 marks ($25), and so on down to 10 francs, which is the smallest amount charged for any peak. Under the Swiss tariff a mountain such as Rainier would probably cost the climber about $30 for the ascent.—*Masama*, December, 1905. Page 218.*

A CONTRIBUTION TO KNOWLEDGE OF THE PACIFIC.—The Smithsonian Institution has just printed (*Bulletin* No. 55 of the U. S. National Museum) a compilation of data collected by the U. S. S. *Nero* while engaged in the survey of the route for our trans-Pacific cable in 1899. The number of soundings was 2,074, or an average of one for every 10 miles of distance run. The survey followed lines as direct as practicable from Honolulu to Midway Island, thence to Guam and Luzon, and also from Guam to Japan.

The *Bulletin* contains an abstract of the official record of soundings showing the position, depth, surface and bottom temperatures, character of the bottom, and deposits; also a record of the detailed examination of selected specimens of deposits from stations on the outward voyage of the *Nero*. A belt of ocean about 14 miles wide and over 6,000 miles long was examined, and the parts of the ocean covered by this very thorough survey are shown by a diagram. It was during this work that the deepest sounding ever recorded was found about 75 miles east-southeast of Guam. This sounding is in 12° 43′ 15″ N. Lat. and 145° 49′ E. Long., and is only 66 feet less than 6 statute miles.

COMMERCIAL RESEARCH IN THE TROPICS.—The Liverpool Institute of Commercial Research in the Tropics has sent its first expedition to West Africa. The five members of the party will visit Dakar, Bathurst, Konakri, and, if possible, the Cameroons. As the expedition is experimental, the visit will be a short one; but if

* It is a small matter, but four marks are equal to a dollar, and the mark is not Swiss.

the results are satisfactory, a second expedition will probably go out to spend a long period in Africa. The present party will inquire especially into the cultivation of rubber—how to improve the quality of West African rubber, and how to protect and increase the present supply. An effort will also be made to find new sources of oils and means of increasing the supply by utilizing the present waste. Investigations will also be made regarding the establishment of hemp, cotton, jute, and ramie growing, and also of new fibres.

KOLONIAL-HANDELS-ADRESSBUCH, 1906.—The latest edition of this invaluable work of reference for all who are interested in the German colonies contains statistics and information concerning their present stage of development, including lists of the colonial companies, traders, farmers, missionary posts, colonial governments, communications, and trade. The work includes maps of each of the colonies. It is published by the Kolonial-Wirtschaftliches Komitee, Berlin.

PERSONAL NOTES.—From May last until the end of the year, Dr. G. K. Gilbert was in the Sacramento Valley, California, studying the regimen of the Sacramento and its branches with regard to the transportation of débris. This work is connected with the investigation of hydraulic mining in the Sierra Nevada in its relation to agriculture in the Sacramento Valley.

Dr. C. Kenneth Leith, Professor of Geology in the University of Wisconsin, is working, in collaboration with President C. R. Van Hise, on a monograph of the entire Lake Superior region—a work that will be a co-ordination and summary of two generations of geological exploration and study in a region of remarkable interest. The work will soon be published as a Geological Survey Monograph.

U. S. BOARD ON GEOGRAPHIC NAMES—Decisions March 7, 1906:

ALAMOGORDO: election precinct and town, Guadalupe county, N. Mex. (Not Alamo Gordo.)

BANCROFT: mountain, on the county line between Clear Creek and Grand counties (southern part of S. 29, T. 23, R. 74 W.), Colo. (Not Lomand's, Millar's, nor Perry Peak.)

BATTIE: mountain, Camden town, Knox county, Maine. (Not Beattie nor Beatty.)

BOULDER: creek, Matanuska valley, 40 miles northeast of Knik arm of Cook inlet, Alaska. (Not Schoonhoven nor Schoonoven.)

*BREWSTER: precinct and town, Okanogan county, Washington. (Not Bruster.)

CHICKAWAUKIE: pond, Rockland and Rockport towns, Knox county, Maine. (Not Cichicwaukie nor Chickawaka.)

DEATH VALLEY: valley, Inyo county, California. (Not Amargosa Desert nor Lost Valley.)

ELBOW: lake, 4 miles east of mouth of Thunder Bay river, Alpena county, Michigan. (Not Carp nor Crooked.)

*HANKOW: capital, province of Hupeh, China. (Not Hankau.)

KINGS: mountain on the east bank of Matanuska river, 40 miles northeast of Knik arm of Cook inlet, Alaska. (Not House.)

LILLY: pond, Rockport town, Knox county, Maine. (Not Fresh nor Lily.)

LITTLE NESENKEAG: brook, tributary from the east to Merrimack river, Hillsboro county, N. H. (Not Chase's, Chases, Massenteean, Mossenteean, nor Reed's.)

* Reversal of former decision.

MONROE: island, southeast of Rockland, Knox county, Maine. (Not Munroe.)

NESENKEAG: brook, tributary from the east to Merrimack river, Hillsboro county, N. H. (Not Brickyard, Chase, nor Great Nesenkeag.)

*NEWCHWANG: treaty port, province of Liaotung, China. (Not New-Chwang, Niu-chuang, Niu-Chwang, Niuchwang, nor Niutschuan.)

SANGERFIELD RIVER: branch of Chenango river, Chenango, Madison, and Oneida counties, N. Y. (Not Chenango Creek, East Branch Chenango river, nor East Chenango river.)

SHANDON: railroad station and village, Butler county, Ohio. (Not Glendower, New London, nor Paddy's Run.)

SOOCHOW: city, China. (Not Soo-Chow-Foo, Soo-Tchoo, Sou-Tcheou-Fou, Su-chau, Su-Chew, Su-chow, nor Su-Chow.)

TALKEETNA: mountains and river, north of Cook inlet, on the east side of Sushitna river, Alaska. (Not Talkeet, Talkeetno, nor Talkütna.)

TEE: cove or harbor, Lynn canal, southeastern Alaska. (Not Stephens.)

TULULA: creek, tributary to head of Cheoah river, and town, Graham county, N. C. (Not Tallulah.)

WALHALLA: plateau, Coconino county, Arizona. (Not Greenland nor Valhalla.)

WINOOSKI: river, tributary from the east to Lake Champlain, Chittenden and Washington counties, Vermont. (Not Onion.)

AMERICAN GEOGRAPHICAL SOCIETY.—TRANSACTIONS, FEBRUARY, 1906.—A Regular Meeting of the Society was held at Mendelssohn Hall, No. 119 West Fortieth Street, on Tuesday, February 20, 1906, at 8.30 o'clock P.M.

Vice-President Moore in the chair.

The following persons, recommended by the Council, were elected Fellows:

Courtlandt Nicoll.
Henry DuBois Bailey Moore.
William McDonald.
Thomas A. McIntyre.
Harry Alvan Hall.
William Maxwell.
James M. Lawton.
Howland Pell-Haggerty.
Edwin Stanton Mullins.
R. Stuyvesant Pierrepont.
James H. Penniman.
George Marvin.
Gouverneur Morris Phelps.
I. N. Poe.
Arthur Sachs.
Henry V. Poor.
Allen Merrill Rogers.
Abbott S. Rogers.
Emmet Queen.
Spencer Eddy.
John K. Robinson.

The Chairman then introduced Professor William Morris Davis, who addressed the Society on Experiences with the British Association in South Africa.

Stereopticon views were shown.

On motion, the Society adjourned.

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* Reversal of former decisions.

NEW MAPS.

AFRICA.

CENTRAL AFRICA.—Vias Navegables y Ferrocarriles, Construidos y proyectados en el Africa Central. Scale, 1:10,000,000, or 157.8 statute miles to an inch. *Boletín* of the Madrid Geographical Society, Vol. XLVII, No. 4, 1905, Madrid.

The navigable parts of the rivers are strongly accented, and railroads in operation, under construction, or projected are indicated in red.

CONGO FREE STATE.—Carte Foncière de l'État Indépendant du Congo. Scale, 1:8,000,000, or 126.2 statute miles to an inch. By A.-J. Wauters. *Le Mouvem. Géog.*, No. 52, 1905.

Shows in colours the distribution of the territory of the Congo Free State; (1) regions owned by certain commercial societies; (2) regions of whose exploitation certain commercial societies have a monopoly for a fixed period; (3) land which the State has assigned to the Crown; (4) a region in which three societies are permitted to operate without a concession; and (5) the private domain of the State.

TUNIS.—Carte Routière de la Tunisie au 1er Juillet, 1905.—Scale, 1:500,000, or 7.8 statute miles to an inch. By the Director General of Public Works, Tunis, 1905.

An excellent map of Tunisia, containing not only detailed information relating to all transportation routes, from railroads to camel-paths, post and telegraph offices, lighthouses, etc., but also a generalization of the surface-forms indicated by light and shade. An inset shows the environs of Tunis on a scale of 1:200,000, or 3.1 statute miles to an inch.

TOGO.—Karte von Togo (E. 1 Misahöe). Scale, 1:200,000, or 3.1 statute miles to an inch. *Mitt. aus den deutschen Schutzgebieten*, Band XVIII, Berlin, 1905.

Another sheet of the 10-sheet map of Togo, based upon trigonometrical and topographic surveys. Dr. Gruner says that the accurate topographic detail collected cannot all be shown even on this comparatively large-scale map.

LAKE CHAD REGION.—Der Deutsche Logone und seine Nachbargebiete. Scale, 1:750,000, or 11.84 statute miles to an inch. By M. Moisel. *Mitt. aus den deutschen Schutzg.*, Band XVIII, Berlin, 1905.

The map is based upon unpublished surveys and astronomically-determined positions. It gives a good idea of the junction, at high water, of the Niger and Shari basins through the Tiburi swamp. An inset gives the plan of Dikoa on a scale of 1:10,000, or 0.1 statute mile to an inch.

LAKE CHAD REGION.—Das Tschadsee-Gebiet. Scale, 1:750,000, or 11.84 statute miles to an inch. By H. Marquardsen. *Mitt. aus den deutsch. Schutz.*, Band XVIII, Berlin, 1905.

Accompanies an article on the exploration of this region by the Yola-Lake Chad expedition. Shows the distribution of forest and scrub around the lake, the extent of the coasts that are flooded at high water, the parts of the lake that are covered by water plants, and the lagoons that are periodically dry or cut off from the lake.

AMERICA.

U. S. Geological Survey Maps.

Geologic Atlas of the United States. Washington, D. C., 1905.

No. 124. Mount Mitchell Folio, North Carolina–Tennessee.

No. 126. Bradshaw Mountains Folio, Arizona.

No. 127. Sundance Folio, Wyoming–South Dakota.

No. 128. Aladdin Folio, Wyoming–South Dakota–Montana.

No. 129. Clifton Folio, Arizona.

No. 130. Rico Folio, Colorado.

Map Showing Pleistocene Deposits of a Portion of Southeastern Wisconsin.—Bulletin No. 273, U. S. Geological Survey.

Illustrates a paper by William C. Alden, in which the data now at hand concerning the drumlins of this region are presented. By far the larger number of drumlins of this area belong to the deposits of the Green Bay Glacier.

Grazing Lands, Western United States (General Location and Area). No scale. Compiled by Albert F. Potter, Bureau of Forestry, U. S. Department of Agriculture. *Bulletin* No. 62 of the Forest Service, Washington, 1905.

Though an expert may figure out the scale of this map without difficulty, it is unfortunate that our Government should issue any maps without providing the common convenience of the natural scale and scale of miles. The map shows the country west of the 100th meridian. Colours indicate the areas of cultivated land, unused desert land, summer, winter, and year-round stock ranges; and also those that are developed by artificial water supplies. This useful map gives a good, general idea of the proportion of each class of land in the different States and Territories.

Preliminary Geologic Map and Sections of Oklahoma Territory. Scale, 20 statute miles to an inch. By C. N. Gould. U. S. Geological Survey, Washington, 1905.

Accompanies Water Supply Paper, No. 148. Contours show the topography upon which the Geological data are imposed.

U. S. Hydrographic Office Charts.

Pilot Charts of the North Atlantic Ocean, January, February, March, 1906.

Pilot Charts of the North Pacific Ocean, February and March, 1906.

New York.—Geological Map of the Paradox Lake Quadrangle. Scale, 1:62,500, or 0.9 statute mile to an inch. Bulletin 362, New York State Museum, Albany, 1905.

The geological detail is imposed upon the topographic sheet of this quadrangle, which covers the southeastern part of the Adirondacks. Most of it is within the gneissic area. Illustrates a paper by Dr. Ida H. Ogilvie.

Porto Rico.—Map of the Island of Porto Rico. To accompany Annual Report of the Bureau of Public Works for the fiscal year 1904–05. Scale, 5 statute miles to an inch. Bureau of Printing and Supplies, San Juan, 1905.

The map, though very roughly executed, shows clearly the general plan of the insular roads completed, under construction, and to be built. About 490 miles of macadamized roads have been built or are under construction.

Chile.—Comisión Chilena de Límites. Sheets: Coquimbo–Aconcagua; Aconcagua; Aconcagua–Santiago; O'Higgins–Colchagua; Llanquihue. Scale, 1,250,000, or 3.9 statute miles to an inch. Oficina de Límites, Santiago, 1905.

Gives the cartographic results of the surveys of the Chilean Boundary Commission along the main Andean range from 31° to 35 S. Lat., and from 42° to 43° S. Lat. Each of the five sheets includes a degree of latitude and about a degree of longitude,

shows the topographical features, and indicates in red the boundary as determined by the Joint Commission. The Aconcagua sheet gives the height of Mount Aconcagua as 22,835 feet, instead of 23,080 feet, as shown in Mr. FitzGerald's map.

DUTCH GUIANA.—Kaart van het Suriname behoorende Stroomgebied van Lawa en Tapanahoni. Scale, 1:500,000, or 7.8 statute miles to an inch. *Tijdschrift* of the Royal Netherlands Geographical Society, Second Series, Vol. XXII, No. 6, Leyden, 1905.

Accompanies a long report on the exploration of the basins of the Lava and Tapanahoni in Dutch Guiana. The confluence of these rivers forms the Maroni River. The Lava River system, forming the eastern sources of the Maroni, is not yet known by that name on the latest atlas sheets. The scale permits the introduction of much detail, as islands, falls, swamps, footpaths, villages of the Bush Negroes and Indians, and also a large amount of information relating to the distribution and heights of the mountain ranges and groups. This is a "mother map," which will be useful for the improvement of our imperfect mapping of the southern part of Dutch Guiana. Insets show profiles of the slope of the Maroni and Tapanahoni Rivers.

PERU.—Mapa de la Provincia del Alto Amazonas. Scale, 1:1,500,000, or 23.67 statute miles to an inch. *Boletín* of the Geographical Society of Lima, Vol. XVII, No. 1, 1905, Lima.

Illustrates an article by C. M. Derteano on that part of Peru mainly east of the Andes and north of 6° S. Lat. The map takes in a large territory in the north claimed by Ecuador.

PERU.—Mapa de los Ferrocarriles del Perú. Scale, 1:4,250,000, or 67.07 statute miles to an inch. *Boletín* of the Geographical Society of Lima. Vol. XV, No. 4, 1904, Lima.

Shows railroads in operation and projected and the proposed line of the Pan-American railroad.

PERU.—Plano de las Secciones y Afluentes del Rio Urubamba. Scale, 1:150,000, or 2.38 statute miles to an inch. By Luis M. Robledo. *Boletín* of the Geographical Society of Lima, Vol. XV, No. 4, 1904, Lima.

A large-scale map of one of the sources of the Amazon indicating many elevations in meters and the velocity of the river in different parts of its course.

PERU.—Mapa Hidrológico. Scale, 15.5 statute miles to an inch. *Boletín* of the Corps of Mining Engineers of Peru, No. 27, Lima, 1905.

Shows areas of canal, artesian, and other forms of irrigation in Peru as far south as 7° S. Lat. This excellent map illustrates an exhaustive monograph on the hydrology of northern Peru.

TRINIDAD.—Sketch of Roads in Trinidad. Scale, 3⅓ miles to an inch. The Crown Lands Office, Trinidad, 1905.

The position of the various ranges of hills is approximately shown, and also the settlements along the common roads, railroads, coasts and streams, so that the map fulfils many of the purposes of a large-scale map.

ASIA.

AFGHANISTAN.—Map of Afghanistan (four sheets). Scale, 1:013,760, or 16 statute miles to an inch. Survey of India, Calcutta, 1905.

This map, which fits into the scheme of a uniform map of the world on a scale of 1:1,000,000, is based upon the latest editions of the Standard Sheets issued by the Survey of India, and includes additional materials derived from other authorities. The scale permits the introduction of much detail that is not found in our Atlases.

CAUCASIA.—Map of Caucasia, Turkey in Asia and Persia. Drawn and Published by the War Topographical Department of the Caucasian Military Division. Scale, 1:680,000, or 10.7 statute miles to an inch. Tiflis, 1903.

Symbols to show towns and settlements according to importance, forts, posts, monasteries, customs houses, rail, waggon, and caravan roads, etc.

CHINA.—(A) Schizzo della Manciuria Meridionale e del Liaotung. Scale, 1:850,000,or 13.3 statute miles to an inch. (B) Porto Arthur. Scale, 1:150,000, or 0.7 statute mile to an inch. (C) Liaoiang. Scale, 1:100,000, or 1.5 statute miles to an inch. *Bollettino* of the Italian Geographical Society, Rome, December, 1905.

These are maps of a large part of the recent scene of hostilities in Manchuria, derived from Russian sources, and giving much more detail than war maps printed for the public contained.

FEDERATED MALAY STATES.—Selangor. Scale, 4 miles to an inch. Compiled at the Revenue Survey Office, Selangor, from actual surveys and various explorations. Revenue Surveys, Selangor, 1904.

The materials enabled John Bartholomew & Co., of Edinburgh, to make a fine map of the State of Selangor, which includes about 3,200 square miles. The information embraces all the place-names, transportation routes, distribution of agriculture and mining lands, many heights above sea-level in figures, and other facts all very clearly expressed.

PERSIA.—Theodor Strauss' Reiserouten im westlichen Persien. Scale, 1:600,000, or 9.5 statute miles to an inch. *Petermanns Mitteilungen*, Jahrgang 1905. Tafel 21. Gotha, Justus Perthes, 1905.

Mr. Strauss has travelled extensively in Western Persia, and this compilation of his map routes contains a great number of hitherto unmapped place-names. The map is based upon route traverses. The author gives a special note upon the pronunciation of place-names. It is noteworthy that his spellings, in many instances, do not agree with those used in the general map of Persia in Stieler's Atlas.

AUSTRALASIA.

NEW GUINEA.—West-Neu-Guinea. Scale, 1:2,000,000, or 31.56 statute miles to an inch. By J. W. Van Hille. *Deutsche Rund. für Geog. und Stat.*, Vol. XXVIII, No. 4, Vienna, 1905.

Illustrates an article on the explorations of Van Hille in Dutch New Guinea in 1902.

AUSTRALIA.—Map of Western Australia. Scale, 1:1,584,000, or 25 statute miles to an inch. (Four sheets.) Office of the Surveyor General, Perth, 1903.

AUSTRALIA.—Map of Western Australia. Scale, 1:3,200,000, or 50 statute miles to an inch. Office of the Surveyor General, Perth, 1905.

In the four-sheet map mentioned above the special features are the definition of the land divisions, gold fields, and agricultural areas by colours. All towns, railroads, telegraph lines, and stock routes are shown.

The one-sheet map gives practically the same information on a smaller scale.

EUROPE.

AUSTRIA-HUNGARY.—Artaria's Eisenbahn- u. Postkarte von Oesterreich-Ungarn. Vierte Neuarbeitung. 6 Auflage, Scale, 1:1,500,000, or 23.67 statute miles to an inch. Artaria & Co., Vienna, 1906. (Price, K. 2.20.)

The latest edition of this superior railroad and postal map, brought up to date and giving cartographic expression to a great variety of information desired by the tra-

veller. Insets show northwest Bohemia, Vienna, Prague, and Budapest on much larger scales, so that, for example, a traveller may easily find the depôt of every railroad entering the large cities.

AUSTRIA-HUNGARY.—Map showing the Races occupying Austria-Hungary. Scale, about 70 statute miles to an inch. *Scot. Geog. Mag.*, Edinburgh, Jan. 1906.

The areas occupied by Germans are tinted red; and red lines show the territorial divisions between the other races. Illustrates a paper on the ethnology of Austria-Hungary by Ralph Richardson.

AUSTRIA-HUNGARY.—The Statistical Bureau of Budapest has issued, in German, a volume entitled "Die Hauptstadt Budapest im Jahre, 1901," in which it gives the census results of that year, and includes a number of finely-executed maps on a uniform scale of 1:45,000, or 0.71 statute miles to an inch, showing the distribution in the city of Roman Catholics, Jews, Hungarians and Germans; also the percentage of inhabitants in each district speaking Hungarian.

EUROPE.—Physik. polit. Schulwandkarte von Europa. Scale, 1:3,000,000, or 47.34 statute miles to an inch. By M. Kuhnert and Prof. Dr. G. Leipoldt. A. Muller-Fröbelhaus, Dresden, 1905.

A school wall-map in which the relief forms are shown by the employment of light and shade, both of which are intensified with increasing height according to a scale of colours printed on the map. Only the most important place-names and railroad routes are given, and the town marks are differentiated according to population. The map presents the broad distinctions between the various land-forms in a clear and vivid manner.

FRANCE.—Carte des Gisements de Coquilles Comestibles de la Côte comprise entre l'Embouchure de la Loire et l'Embouchure de la Vilaine. Scale, 1:80,000, or 1.2 statute miles to an inch. By Prof L. Joubin.

Shows the distribution of edible shellfish along the Atlantic coast of France between the Loire and the Vilaine, and illustrates *Bull.* 59 of the Oceanographical Museum of Monaco.

ICELAND.—Hohenschichten-karte von Island. Von. Th. Thoroddsen. Scale, 1:750,000, or 11.8 statute miles to an inch. *Petermanns Mitteilungen*, Ergänzungsheft No. 152. Gotha, Justus Perthes, 1705.

The map accompanies the first part of a monograph by Professor Thoroddsen on the geography and geology of Iceland. This geographer is widely known for his long studies and surveys in Iceland, which have made the geology, surface-forms, and other features of the interior known to geographers. The elevations of the land are shown by nine tints, ranging from sea-level to over 1,500 meters above the sea. An inset of the island shows the cultivable land, deserts, and lava-covered areas and regions where grass may be found for horses, and glaciers.

RUSSIA.—Die Deutschen in Russland. Scale, 1:10,000,000, or 157.8 statute miles to an inch. By Paul Langhans, With insets showing the German Colonies near St. Petersburg and in Moscow. *Deutsche Erde*, No. 6, 1905. Gotha.

Shows the distribution of the Germans in the various governments of Russia. They are most numerous in an area of Poland south of Warsaw, where they form more than one-tenth of the population.

POLAR.

ANTARCTIC.—Map showing zones of vegetation round the South Pole. By C. Skottsberg. *Ymer*, No. 4, 1905, Stockholm.

SOUTH AMERICA.—Phytogeographical Map of Fuegia and South Patagonia.

On the basis of P. Dusen's map. Scale, 100 kilometers to an inch. By Carl Skottsberg. *Ymer*, No. 4, 1905, Stockholm.

These two maps illustrate an article by the botanist and Antarctic explorer Skottsberg on the geographical distribution of vegetation in the colder part of the southern hemisphere. The phytogeographical Antarctic chart shows the botanical information in red on a South Polar Chart. The map of the southern part of South America shows the limits of evergreen and deciduous beeches.

ATLASES.

GERMANY.—Bodenanbau und Viehstand in Schleswig-Holstein. Nach den Ergebnissen der amtlichen Statistik. By Th. H. Engelbrecht. 36 sheets and 144 inset maps. Chamber of Agriculture, Kiel, 1905.

Exhaustive information relating to all the agricultural and stock-raising interests is here graphically given in colours.

GEOGRAPHISCH-STATISTISCHER UNIVERSAL-TASCHEN-ATLAS. Von Prof. A. L. Hickmann. 64 pp. of Text, and 64 Tables, Diagrams, and Plates. G. Freytag & Berndt, Vienna, 1905. (Price, k. 4.50.)

This pocket atlas contains 64 sheets of maps, diagrams, and plates, besides 64 pages of text, with a large variety of geographical information, such as the areas and population of the continents, their highest points above sea-level, the largest islands, the most important lakes, the distribution of races and languages, statistical information, etc. The maps are not so finely executed as those in some other pocket atlases, but, on the whole, their information is accurate and up to date. The latest railroad extensions in Africa, for example, are given. The western world and Asiatic countries are very meagrely treated in comparison with Europe. In both maps and text the book contains a very large amount and variety of compact information.

THE OXFORD ATLAS OF THE BRITISH COLONIES (Part 1). British Africa. Seventeen plates in colour. William Stanford & Co., Ltd., Oxford Geographical Institute, Oxford, England. (Price, 2s. 6d.)

The first of a series of atlases embracing the colonies of Great Britain which this firm is now bringing out. Many of the maps are rather rough, but perhaps nothing better can be expected in a quarto atlas of 17 plates selling at retail for a half crown. The first plate is hemispherical, with Cape Town at the centre of projection and parts of the projection extended beyond the hemisphere, to show the relation of South Africa to Australia and our Atlantic ports. The isotherms for Africa are not reduced to sea-level, the object being to indicate the mean temperatures actually experienced in different parts of the continent. The physical map has no differences of tint for heights above 5,000 feet, with the result that no distinction is made between the high Abyssinian plateau and others that are thousands of feet lower; and as for the highest mountains, their elevation is not indicated in any way. On most of the colony maps there is space for much more information than is given, and we miss such desirable facts as the distribution of gold, coal, and diamond mining, etc. A name is occasionally misspelled, as the Sankaru for the Sankuru River. Railroads are especially emphasized on the political map of the continent, but there is no indication of the railroad around the rapids of the Lower Congo, one of the most profitable and successful railroads in the tropics.

BOOK NOTICES.

L'Évolution de la Terre et de l'Homme. G. Lespagnol. Paris, Librairie Ch. Delagrave, 15, Rue Soufflot, 15. (Pr., 5 fr.)

A handbook of general geography, differing in its plan in various respects from that usually followed in similar American publications. It is natural that in the country of Vivien de St. Martin a book on geography should be considered incomplete without an account of the historical development of the science, and the emphasis given to the evolutionary side of the subject, as shown in the mere title, which is quite unique in the application to such a book, likewise requires it. The product of the author's effort does not fall short of his intentions; it will be difficult to find a better presentation, in the same limited space, of the evolution both of geographical discovery and geographical science than that given by him in the 107 pages of the first part of this course. Illustrated by reproductions of famous old maps, these chapters are far from being a dull treatise on things entirely of the past; they demonstrate very well how much the truly scientific conception of a subject gains by the knowledge of its gradual progress from the earliest beginnings to its present state, and richly repay the reader for the trouble taken in learning French. It goes without saying that in a country so famous for its cartographic achievements the explanation of the principles of scientific map-making is included in the discussion of scientific geography.

This discussion culminates in an attempt at a definition of geography which, however, is not fully satisfactory. The author says, indeed, a great deal about the object and purpose of geography, what it does, and what it used to be and no longer is, in much the same way as is done in all the newer books and periodicals. But for a new, brief, and clear definition of what this new geography really is, he leaves us no wiser than we were before, and in fact never gets beyond the start that it is one of the earth sciences.

His division of the special fields of geography, too, seems open to criticism. He distinguishes mathematical, physical, and "human" geography (geography of man), placing the geography of plants and animals as subdivisions with physical geography, and economical geography as part of the geography of man. In the arrangement of his book, however, the author does not adhere to this scheme, for the historical part is followed by (II) mathematical and physical geography including bio-geography), (III) geography of man, and (IV) economic geography. Under this plan the second part comprises about 350 pages, the third part about 80, and the fourth (a large percentage of which is more technological than strictly geographical) about 170. Even aside from this lack of proportion, which does not correspond to the comparative amount of presentable matter in each of the divisions of the science, the classification according to inorganic conditions and organic responses, as practised by the leading American and German geographers, seems to be more in harmony with the development of geographic research in the last decades.

In spite of these objections of a more theoretical nature, the book, both with regard to the choice and the handling of the subject-matter, ranks with the best productions of its kind in any country, and the concise and lucid presentation of the various topics shows at its best the eminently scientific character of the French

language, giving an additional interest to the book for a reader who has already become familiar with its contents through the medium of another language. The illustrations, while of uneven merit, are almost always really illustrative, and the excellent résumés of the topics treated which accompany each chapter will prove most serviceable for the more mechanical part of the work. Finally, the carefully-selected bibliographical references on each subject, in which foreign names occur quite as often as French ones, cannot fail to give the student a touch of that broader scholarship which will not be acquired at all by the mere textbook-grinder, and only with difficulty by him whose references are limited by national boundaries. M. K. G.

Klimalehre der alten Griechen nach den Geographica Strabos. Von Dr. Hans Rid. Kaiserslautern, 1904. Small 8vo. Pp. 62.

It is significant that, with the rapid advance of modern scientific climatology, so much attention should of late have been paid to the views on climate held by the ancients. The recent works of Berger, Kiepert, Tozer, not to mention other authors, have done much to stimulate and interest in the history of ancient geography and related subjects. Among the geographers of the old days Strabo occupies a prominent place, and it is fitting that his contributions to climatology should be considered at some length in the volume before us. It may surprise those who have not some acquaintance with Strabo's writings to know that a small octavo publication of more than sixty pages could be devoted to the views held by Strabo on climate, at a time when the ideas of even the most advanced thinkers were, as a whole, extremely crude in regard to scientific matters. Dr. Rid has, however, in a sympathetic and in no uncertain way, set before us the contributions to climatology which we owe to the man who has been called "the greatest geographer of antiquity." We welcome this little volume to a place beside the latest of the present-day publications on climatology.

Strabo accepted the five-zone division probably suggested originally by Parmenides (see this BULLETIN, XXXVII, 1905, 387-388), but thought that the zone which was believed to be uninhabitable by reason of excessive heat was not as wide as the stretch from tropic to tropic, as had been supposed.

While recognizing the importance of insolation in controlling climate, Strabo appreciated the part played by temperature, by wind and by humidity. He stated the well-known fact that a movement of the air makes high temperatures easier to bear, while a calm makes low temperatures less bitter. An effect of sunshine upon the colour of the skin and in causing the hair to become crinkly Strabo thought possible only when the air is damp. The importance of monsoon winds in controlling climate, and of wind as a health-giving factor, were appreciated. One of Strabo's greatest contributions was his recognition of the control of surface features over climate, whereby *solar* climate is modified into *physical* climate, and his explicit statements regarding the importance of altitude in causing a decrease of temperature. His predecessors had in some cases suggested such a relation, but he himself first clearly discussed it. Latitude was thus shown not to be the sole cause of differences of temperature. The snow-line was spoken of, as was the difference in altitude above sea-level at which snow falls and remains on the north and south sides of mountains. Mountains were seen to affect rainfall and to act as climate barriers. The influence of local climates upon the distribution of many plants was recognized.

Among the most interesting of Strabo's views were those concerning the in-

fluences of climate upon man. He supported Hippocrates in the belief that weather changes are important in developing physical and mental well-being. He pointed out that nomads are forced to their peculiar mode of life by lack of food and by unfavourable conditions of climate. Mountain peoples are believed to be stronger than lowland peoples, because of the harsher climate in which the former live. The inhabitants of the colder northern latitudes are used to a severe climate. The dweller in the south is soft, and if he goes into a more severe climate cannot endure.

These suggestions concerning Strabo's contributions to climatology will make it plain that we owe much to this ancient writer. Dr. Rid has done well to emphasize the importance of Strabo's scientific work along these lines.

R. DEC. W.

Geografía de la Provincia de Córdoba, por Manuel E. Rio y Luis Achával, Ingenieros Civiles, Catedráticos en la Universidad Nacional de Córdoba. (*Escrita por Encargo del Excmo. Gobierno de la Provincia.*) Publicación Oficial. 2 vols. 8°, and Atlas, in folio. Buenos Aires: Compañia Sud-americana de Billetes de Banco. 1904.

Official publications emanating from the Governments of South-American Republics are, usually, very presentable books. The Argentine especially distinguishes itself, not only in the make-up of its scientific books, but also in the intrinsic value of their contents. The one before us is a fair specimen of official bookmaking in the great Republic of the Pampas and La Plata. Two portly volumes and an atlas in folio, dedicated to the geography of the Province of Córdova exclusively, are certainly well worthy of careful comment. In them, the term "Geography" is taken in its widest sense, as embracing descriptions and statistics of as good as everything connected with the territory mentioned.

The authors, two civil engineers of high standing in their country, have spared no pains in the accumulation and co-ordination of their abundant material. A respectable portion of that material appears to have been gathered (though the fact is not mentioned) by the authors themselves, and the selection made of Messrs. Rio and Achával for the task of preparing this "Geography of Córdoba" is fully justified by the result. It was no small task to do justice to the instructions received from the Executive of the Province, covering as they did, broadly and in the minutest detail, all the subjects of inquiry.

A bibliography, apparently quite complete as far as modern sources are concerned, precedes the text proper. It might, however, have been advisable to include some indications concerning older sources, especially such as are still in manuscript. While we cannot expect to find, in the writings of past centuries, many systematic data, still they often contain allusions which even modern science may advantageously consider. At any rate, where ethnography is included in the material, early history should find its place with proper references to the sources whence knowledge about earliest conditions may be derived. Among the (modern) investigators of the natural history of Córdoba, to which the report alludes, the Germans occupy perhaps the first place, in numbers and in the importance of their achievements; still, there is quite a respectable array of collaborators from the Argentine, as well as from other countries. Full reference seems to have been made to every author, and due credit given to his work.

The descriptions of the physical aspect of the Province are attractive and—what considerably enhances their value—free from the exuberance sometimes dis-

agreeably conspicuous in Spanish-American literature. The few and rare poetic efforts become, through their thorough justification and adaptation to truth, the more pleasing and refreshing.

Situated nearly in the centre of the Argentine Republic, the Province of Córdoba lies between lat. south 29° 30′ and 35°, and long. W. of Greenwich 61° 47′ and 65° 47′. It covers an area of about 175,000 square kilometers (67,570 sq. m.), traversed by several mountain-chains, the highest points of which rise to nearly 2,900 meters (9,500 feet) above the sea. A long list of hypsometric data is given, every one being referred to its source with scrupulous care, which, of course, renders it of solid value. Much attention, also, is shown to the hydrography of the province, in regard to which the most minute care is displayed. The climate of Córdoba having been the object of thorough study on the part of Dr. O. Doering, his work is acknowledged by the authors as their principal basis, whereas the observation tables are taken from the records of the Argentine Meteorologic Office. Many of the tables extend over a period of twenty-five years, and they embrace almost every climatologic feature, ozone included. The distribution of rainfall, as shown by the tables, is interesting through its variety.

It is with some surprise that we note, in a work of such extent and detail, the absence of information on palæontology, whereas the geology of the Province is the subject of reasonable attention. The list of minerals is not only long, but accompanied by observations tending to initiate laymen into a general notion of the minerals enumerated and their value for technical purposes, so far as known. This section of the book is of value to the prospector and miner.

A careful review of the flora and fauna bears out the promise of the bibliographic introduction. In that introduction we already find that, out of seven hundred species of birds known to exist in the whole Republic, 256 are found in the territory of Córdoba. From the section on insects we gather that about a thousand species of Hymenoptera have, so far, been observed in the Province, among which Formicidæ appear with ninety and Mutillidæ with a hundred. Nearly the same number of species of Coleoptera have been recorded, among them 350 Cerambycidæ, Chrysomelæ, and Lamellicorniæ.* Butterflies, however, are rather poorly represented, both in species and individuals, there being hardly more than one-third of the number of kinds of the preceding orders. An interesting observation is that of the comparatively large number of terrestrial molluscs, mostly inhabiting the mountainous districts of the Province, while one species (*Succinea cornea*) dwells in the alkaline regions. The Lamellibranchiæ seem to be represented by a single species, which forms pearls of irregular shape, though of fine lustre, in its cavity.

Political Geography occupies fully one-fifth of the first and two-thirds of the second volume. While the Province is, in size, the second of the sixteen that compose the Argentine Republic, it still embraces but one-sixteenth of the total area of the land. Not quite three persons correspond to every square kilometer. Of the population (about 450,000) but very few are direct remainders of the Indian tribes that held the soil originally. The natives disappeared rapidly, not in consequence of excesses committed by the Spanish colonists, but in the natural course of contact, and on account of their indolence and physical weakness. Only the ferocious Puelches maintain themselves in

* The text has Gamellicorniæ.

the extreme south of the Province and were in the last decades of the nineteenth century still a threat to the peaceable settlements of agriculturists. At present the foreign population represents more than twelve per cent of all the inhabitants, whereas the proportion of foreigners to natives, in the Argentine, is one to four. Italians constitute the greatest number of immigrants, then follow the Spaniards and the French. Numerous statistical tables present various phases in touch with the conditions of the people. The lengthy sections devoted to Agriculture, Government, and Laws are valuable to the visitor and immigrant who wishes to inform himself on the chances and drawbacks presented to him in the Argentine.

The report finally goes over into the geographic description of the Departments into which the Province of Córdoba is subdivided. Much of this being, of necessity, a repetition of the preceding, we forbear entering into details about it. On the whole, the two volumes are a valuable addition to geographic and statistical knowledge, and important to the traveller as well as to intending colonists. While there is, of course, an easily discernible tendency not to diminish the beauty and resources of the Province, it seems to be wholly justified. A handsome Atlas in folio accompanies the very well-printed text. Among South American official publications this one by Messrs. Rio and Achával will always hold a worthy place. A. F. B.

Ueber die Küstenbildungen des Bottnischen Meerbusens zwischen Tornio und Kokkola. Akademische Abhandlung von I. Leiviskä. Helsingfors, 1905. K. Malmström, Publisher. 225 pp. Two maps.

The coast of Finland between Tornio and Kokkola—viz., between 64° and 66° N.—differs from other parts of the coast of the Gulf of Bothnia through the lack, or very limited number, of islands. While a general family resemblance is evident in all parts of the region described, its features present some perfectly distinct types. Sometimes a great number of them are crowded together on a limited area, sometimes the character of the coast remains unchanged for many miles. Upon the basis of a minute study of every part of the coast from Kokkola to Tornio, the author gives a classification and explanation of the various types. Examining the larger or smaller number of bays, necks, and islands, their shapes, the steepness of the coast, the material of which it is built, etc., the author distinguishes five principal types—meadow, pasture, sandy, stony, and rocky coasts.

1. Meadow coasts occur on sandy and clayey shores. The sand meadows occur (*a*) in open bays, near the mouths of rivers; there the sand is purest, and a gentle surf arranges it in long sandbanks and lagoons, or swamps, alternately; (*b*) in sheltered bays, on gently rising shores, on which the meadow generally passes into groves and forests. Here the sand is freely mixed with clay. Clay meadows, on the other hand, occur in shallow water where there are no rivers, and the coast is rich in low islands separated by shallow channels. It is on these meadows that are found the so-called "barren polygons"—a formation due to the cracking of the clay in dry weather and the rising to the surface, along the cracks, of salt water which evaporates and leaves salt crystals all along the cracks, thus covering the soil with a network of white polygons.

Substages of the meadow coast are the shrub coasts, narrow strips of meadow covered with shrubs, and the bluff coast, due to erosion.

2. The pasture coasts are distinguished from the first type by the occurrence

of boulders and vestiges of forests, and they are classified as sand pastures with a sandy, and boulder pastures with a clayey, soil.

3. Sandy coasts occur only on the open ocean, not in bays. They are either wide sand beaches or narrow strips of sand before a rocky coast, running straight or in a curved line, and are always accompanied by parallel ridges of dunes running also straight or curved, respectively. It is very significant that a long plateau of sand always extends from such a coast out into the ocean, and that, contrary to (*a*), they appear absolutely independent of the mouths of rivers. This would contradict the statement of Sokolow that the distribution of permanent dunes on the coast coincides with the arrangement of river mouths, whither sand is transported by the rivers. Here it seems that the submarine sand plateau furnishes the material for the dunes, each incoming wave depositing a load of sand on the shore and the undertow washing the light particles again out into the sea. On a rising coast like this one, the continuous gain of land and the parallelism of the dunes to the shore seem to correspond very well in support of this theory.

4. The stony coasts are either pebble coasts, along the shores of necks and on the outside shores of islands, or boulder ("block") coasts on the inner sides of the bays. They are but partly of glacial origin; much credit for their existence must be given to the transporting powers of coastal and river ice in this region. One can easily tell the two kinds of deposits by their scratches, those of the recently-transported material being more superficial and less regular.

5. On the rocky coasts proper, granite and gneisses appear in more or less rounded hills, both as hills on the land and as islands in the ocean. Where the waste has connected the islands with the mainland and among themselves, a beautiful forested coast is the result. The same care as under 4 must be taken in attributing the shape of these hills to glaciation alone. While they are unmistakably *roches moutonnées,* their original curvature is very probably due to rock structure. It has been observed that this particular granite has a distinct tendency to break in concentric layers, and thus glacial action is probably responsible only for the final polishing and the scratching of the rock.

Of terraces, none but pseudo-terraces are found, either where in front of a pebble or boulder wall a narrow strip of meadow has been formed, or where on the shore meadows the action of the waves has worn out a bluff with a beach below.

The hardness and shape of the subsoil determine the topography of the region to this day, with the only exception of a depression in the central part of the coast where the rock surface is so low that considerable deposits of sediment were made in the stage of submersion, and their shape is now determined by the action of the waves and rivers. Even the islands, however, are nothing but elevations of bed rock clothed with sediments, and both the bottom of the sea and the surface of the back country repeat the same general lines of structure which are exhibited on the coast.

The book is illustrated with a large number of excellent photographs, and is a valuable contribution to the geography of Finland, as well as to the geography of the coasts in general. M. K. G.

British Rainfall.—Few meteorological publications are more widely known than *British Rainfall*, a report which is unique in meteorological literature. The forty-fourth volume has been reached, and bears the date 1905. Dr. H. R. Mill, the present compiler of the report, succeeded the late Mr. G. J. Symons, who

organized the British Rainfall service, and edited the annual volume for thirty-nine years. The peculiarity of this rainfall organization is its voluntary, unofficial character. By years of continued hard work Mr. Symons was able to build up a system which embraced all parts of the British Isles, and brought together a remarkable series of rainfall records, and the support of this service was obtained through the voluntary contributions of its observers. Dr. Mill is carrying on the work with unswerving devotion to the ideals of its founder. The present volume contains data supplied by 3,982 rain gauges, set forth in the usual way. In addition, there are original articles on the rainfall of Ben Nevis, and other matters of more local British interest. A valuable part of the report is a discussion of *Heavy Falls on Rainfall Days in 1904*, in which the paths of the cyclones which brought these heavy rainfalls are charted, together with the rainfall distribution. This makes it possible to study the relation of precipitation to the cyclonic unit, rather than to the daily or monthly unit. R. DEC. W.

Commercial Geography. By Henry Gannett, Carl L. Garrison and Edwin J. Houston. vi and 440 pp. 185 Figures and Index. The American Book Company, New York, 1905.

Gannett, Garrison and Houston's Commercial Geography is the latest addition to the rapidly-increasing number of commercial texts for use in high schools, and is in many ways a striking contrast to most of its American rivals. Commercial Geography has not been taught long enough in this country for experts to come to an agreement as to what the subject should include or what emphasis should be given to the different phases. Two plans prevail as to the content of texts. Under one plan, illustrated in the well-known books by Adams and Trotter, a brief consideration is given to the general principles of the subject, and the rest of the space is devoted to Regional Commercial Geography.

Redway's Commercial Geography and the book under review follow the other plan, evidently adapted from the English master Chisholm, of dividing the treatment into three parts—Commercial Conditions, Commercial Products, and Commercial Countries.

The proportionate space given to these different phases in the five leading texts is indicated by rough percentages in the following table:

	GENERAL PRINCIPLES.	COMMODITIES.	REGIONS.
Adams.....	10%	—*	90%
Trotter.....	12%	—	88%
Redway.....	22%	28%	50%
G. G. & H....	20%	20%	60%
Chisholm.....	13%	27%	60%

For practical purposes the general plan followed in the book under review is probably the best, though it involves such a condensation of material that the study of the text leads to memory work rather than to a realization of the principles of commercial geography.

The authors have given a good summary of the conditions determining commerce, with a better emphasis of the economic determinants than is found in any other American book. The physical side is, on the other hand, fragmentary, and some-

* About 40 per cent. of Adams's book, including product maps, is given to commercial products. As the general principles of commercial geography are not confined to the first six chapters, but are applied throughout the book, the bases of the subject occupy much more than 10 per cent. of the space.—EDITOR.

what unsatisfactory. The treatment of products is generally well done, though it would have been improved if many of the products of lesser importance had been omitted. The regional treatment is good. The book is supplied with an excellent series of percentage diagrams and black-and-white distribution maps. The statistical tables are well selected for reference work, and the index is full and most serviceable.

The volume is excellent for a trained teacher who has a good laboratory equipment to be used in a supplementary way. We have tested the results of the book in one instance and found a large amount of information of unrelated facts and little real knowledge—a condition that might arise with even an ideal book in the hands of an untrained teacher. In many ways the volume is the best in the market, and is a step in advance. For classes in the later years of a high school we should prefer a volume with a little more emphasis of causes and consequences and fewer details. R. E. D.

Zur Kunde der Balkanhalbinsel. Reisen und Beobachtungen. Herausgegeben von Dr. Carl Patsch. Heft 1. Eine Reise durch die Hochländergaue Oberalbaniens. Von Karl Steinmetz. 66 pp., 13 Illustrations, and Route Map. Heft 2. Aus Bosniens Letzter Türkenzeit. Von Dr. Josef Koetschet, vii and 109 pp., with portrait of Dr. Koetschet. Heft 3. Ein Vorstosz in die Nordalbanischen Alpen. 60 pp., 10 Illustrations, and a Map. A. Hartleben, Vienna, 1904–1905. (Price, M. 2.25 each.)

The publishing house of A. Hartleben is to be commended for beginning the publication of this series of travels and observations in the Balkan Peninsula, for they promise to throw some new light upon this obscure part of the world. In his travels in the mountain region of northern Albania, Engineer Steinmetz, for example, almost within sight of Scutari, fell in with phases of life that would seem more characteristic of some earlier century. Girls and women on the road were bending under heavy burdens which they were carrying to the market towns. Men, on the other hand, carried only their fine rifles. The explorer saw only one muzzle-loader among the mountaineers, who are fully abreast of the times in the value of their guns.

The first night out from Scutari Steinmetz became accidentally the guest of the celebrated outlaw, Kin Matija, who lives by nightly forays upon the plain dwellers, and seems to live in perfect security among his mountains, though the Turkish Government has set a price on his head.

Among these mountains the first questions that all men asked Steinmetz were, "Who are you?" and "Where did you come from?" He thought it most fortunate that in this lawless land there is an unwritten law which is protective in its effect. In whatever house he ate a piece of bread, or even drank a glass of water, he was henceforth a friend of that house, and any injury to him would probably be avenged.

Steinmetz's two journeys were in the basin of the middle and lower Drin, which had already been studied on the geographical side by Hassart, von Östreich, and Consul General von Ippen. The explorer's two maps show a region divided by parallel ranges, and deep, very narrow valleys, into natural mountain districts, where it would be very difficult, without large sacrifice, for the Government fully to impose its authority upon the people. Steinmetz comments on the barrenness of the upper parts of the mountains and the distances of the small settlements from one another.

Le Origini degli Stati Uniti D'America. Gennaro Mondaini. pp. xvi + 460. Ulrico Hoepli, Milano, 1904.

The physiographic description of the territory of the United States that opens this well-intended volume is concise, but quite sufficient for the scope of the book. The chapter about the Moundbuilders might have been shorter for what it really con-

tains, as in statements like these: "Edifices constructed on the tops of hills and containing as many as 5,000 persons"; and, "Or are these the monuments of that great civilized empire founded, as the Iroquois tradition tells, by the Indian tribe of the Lenni Lenape, who came into the valley of the Mississippi from the North-west, and were driven out by more barbarous peoples, who forced them to take refuge in the most inaccessible *cañons*, where are still found remains of extraordinary buildings?"; or, again, "finally Morton, with perhaps sounder judgment than any, attributes them to that Toltec type represented by the primitive inhabitants of Mexico—a type physically distinct from the true North American, because it is dolichocephalic rather than brachycepalic."* (Pp. 21 and 22.) These show that the author still comfortably reposes in what was once thought to be true. To the same class of information belong the discourses about the "Great Spirit" of the American Indians (p. 25).

As with the overwhelming majority of European writers on these topics, a guileless faith in the knowledge of our forefathers characterizes the author's point of view and leaves it an open question whether the briefness of his remarks on the subject of the primitive inhabitants of North America might not, perhaps, have been more decided. The same kind of "archaic" knowledge is displayed in the short review of Spanish attempts at colonization of the North American coast.

Mondaini's conception of the merits of Puritan colonization is not always impartial. The great influence which the Puritans have exercised over the development of what is now the United States appears to him a logical sequence of the principles of Puritanism. But he is not an admirer without reserve, for he remarks (p. 80): "If this rigidity, which soon degenerated into an intolerance that prohibited everything 'but marrying and making money,' renders the Pilgrims less attractive to us, it is certain, on the other hand, that this sovereign contempt for whatever gladdens and embellishes life contained within itself the assurance of success in that hard country."†

The maxim to "marry and make money" has, as far as the second part of it is concerned, become one of the strongest survivals of Puritan influence in this country. In regard to the first part there have been modifications, to which the tendencies of the "Puritan forefathers" are not altogether foreign.

Handsome is the tribute paid to Roger Williams, and without a consequent stringency towards the intolerability or intolerance of the Puritans. Mr. Mondaini's admiration for the latter leads him to attribute to them almost every noticeable feature or deed with which the people of the United States can be credited.

Whereas, in the second chapter, the author has hardly sufficient praise for the Puritans, in the third the colony of Jamestown, Virginia, is roughly handled. He calls the founders of that colony adventurers of the worst kind ("Erano essi avventurieri della peggior specie), and similar "names," that show his ultra-democratic, not to say socialistic, inclinations, and detract henceforth much from the value of the little work. Hereafter Mondaini far exceeds George Bancroft, in the latter's Apology

* "edifici costrutti in cima ai colli e contenenti persino 5000 persone," and "O sono questi i monumenti di quell' impero grande e civile fondato, come suona la tradizione irochese, dalla tribù indiana dei Lemni Lenapi, scesi dal nord-ovest nella vallata del Mississippi e scacciati di qui da genti più barbare, che li avrebbero costretti a cercare rifugio nei più impraticabili *cañons*, dove pur trovansi vestigie di costruzioni stranissime?" Or "il Morton infine, con più ragione forse d'ogni altro, li attribuisce a quel tipo Tolteco, rappresentato pure dagli abitanti primitivi del Messico, tipo distinto fisicamente da quello nord-americano vero e proprio per essere dolicocefalo anzichè brachicefalo."

† Se questa rigidità, degenerata ben presto in una intolleranza che tutto proibiva se ne eccettui "maritarsi e guadagnar denaro," ci rende meno simpatici i Pellegrini, certo è d'altra parte che questo disprezzo sovrano per quanto allieta ed abbellisce la vita portava in sè la garanzia del successo in quel rude paese...

of Puritanism called, by title and courtesy, the History of the United States. He is manifestly a sincere socialist who, however (even in case he visited the United States), has not penetrated beyond the surface, and is imbued with sympathies and ideas becoming more and more antiquated. Distance has lent enchantment to his view; and while there is no sign in his book of any overdose of "book-learning," the almost exclusive reliance upon sources of a certain kind greatly mars the importance of his otherwise well-meant effort.

A good Italian translation of the Declaration of Independence and of the Constitution of the United States is appended. A. F. B.

La Republica Argentina, nelle sue Fasi Storiche e nelle sue attuali Condizioni Geografiche, Statistiche ed Economiche, di Ezio Colombo. Con Tavola, Carta, e Indice dei Nomi. pp. xii + 330. Ulrico Hoepli, Milano, 1905.

This little book is, in fact, a guide to immigrants; and if we consider that between the year 1857 and the end of December, 1902, more than two millions of foreigners settled in the Argentine (of whom nearly one million three hundred thousand were Italians), the timeliness of such a booklet becomes quite apparent. At present one-third of the inhabitants of the country are Italians or descendants of Italians. Among these, fifty per cent. are from southern Italy; next in numbers come the Genoese. Of the latter the book very justly says: "To tell the truth, there is no corner of the New World into which they have not penetrated." This is especially true of the western coast, where the Genoese began to arrive in the fifth decade of the past century, and in greater numbers since 1849 in California. As an element of advantage to the country, the northern Italians (Piedmontese, Lombards, and Venetians) are placed in the foreground, being generally tillers of the soil; whereas the southern Italians form a rather floating population, and the Genoese have almost monopolized the higher branches of finance and commerce.

True to the special task which the author seems to have proposed to himself—to wit, that of making his countrymen acquainted with the Argentine, its resources, and inducements for immigrants—he goes on describing the land, after giving a sketch of its political history. This résumé is well co-ordinated, and its tone is quite impartial. The short allusions to the primitive ethnography of the country are, while not always strictly exact, still satisfactory on the whole. There follow chapters on economical questions, concise but correct pictures of the Fauna and Flora, on Geology and Mineralogy, interesting chapters devoted to Orography and Hydrography. The second half of the little volume contains the descriptions of the various provinces, and, appended, a catalogue of works advertised in the *Manuali Hoepli*, published at Milan. As a guide the book is of a superior type; it bears a decidedly scientific character of the popular kind, and is useful, not only to those who consult it for purposes of emigration, but to the general reader and student of geography and natural history. A. F. B.

The Coal-Fields of Great Britain: Their History, Structure, and Resources. By Edward Hull. Fifth Edition, Revised. xxii and 472 pp., 15 Maps and Illustrations and Index. Hugh Rees, Ltd., London, 1905. (Price, 14s.)

The new edition of this authoritative work is welcomed as supplying the latest information on the subject. The book embodies the results arrived at by the Royal Coal Commission of 1904, describes, in addition to the coal fields of Great Britain, those of the Indian and Colonial Empire and of other parts of the world, and con-

tains small maps of the various British coal fields. The author shows that the increase of temperature in coal mines must be overcome by artificial means when the depth exceeds 3,000 feet, where the temperature of the earth is about 98°. It is assumed that a depth of at least 4,000 feet may ultimately be reached in coal mining.

Austria-Hungary, including Dalmatia and Bosnia. Handbook for Travellers. By Karl Baedeker. Tenth Edition, Revised and Augmented. xviii and 468 pp., 33 Maps, 44 Plans, and Index. Karl Baedeker, Leipzig, 1905. (Price, M. 8.)

This compact guide-book is adapted for a pocket of moderate dimensions. For purposes of description the empire is divided into ten districts, each of which has a section in the book ; and any section may be separately removed from the volume. The maps and plans of Wagner & Debes are unusually numerous, and special care has evidently been bestowed upon them.

Tom Petrie's Reminiscences of Early Queensland (dating from 1837). Recorded by his Daughter. xv and 320 pp., 17 Illustrations, and a List of Places, Names, etc. Watson, Ferguson & Co., Brisbane, 1904.

Mr. Petrie was taken to Queensland in 1837, and was intimately associated with the aborigines of that colony from boyhood. His records of their customs, traditions, and folklore have undoubted ethnological value. His knowledge of these primitive people was intimate and profound, and his daughter has rendered a service in thus perpetuating in book form these graphic memories of the old Brisbane blacks, who have now practically died out. Two-thirds of the book is given to descriptions of the life and ways of these blacks, in whose trustworthiness, if well treated, and other good qualities Mr. Petrie has more confidence than most of the white immigrants. The remainder of the volume gives many incidents of those pioneer days, in which both whites and blacks took part.

Mr. Petrie, on one occasion, accompanied the explorer Leichhardt through the bush and helped him to collect plants and seeds. It was not long after that Leichhardt and his comrades entered the unknown interior, and no particulars of their fate have ever been received.

Unter Chinesen und Tibetanern. Von A. Genschow. 384 pp., 189 illustrations, and 6 maps. C. J. E. Volckmann, Rostock i. M., 1905. (Price, M. 6.)

The author, an interpreter, travelled south from Peking to Hankow, up the Yangtse to Ichang, over the mountains on the south side of the Yangtse to Lichwang and on to Tibet and Burma by way of Talifu, in Yunnan. In the western part of China, as far as Tali, he travelled over some new ground, and added new facts to the descriptive literature of that region. The routes he chiefly followed, however, are fairly well known. The narrative is full of incident, and the book gives a rather graphic picture of the people and the regions visited. Many photographs help the text.

United States Dictionary of Altitudes.—The fourth edition of this important work contains 1072 pages, and is thus very greatly enlarged over the earlier issues. The rapidly multiplying bench-marks of our Topographic Survey and the large number of new determinations by railroad companies have caused this great addition to the number of ascertained altitudes. They are arranged alphabetically under the States and Territories, with the authority for the height given in each case.

OKANOGAN
WASHINGTON
YAKIMA
ST MARY
UMATILLA
OREGON
PAYETTE-BOISE
KLAMATH
MINIDOKA
TRUCKEE-CARSON
NEVADA
STRAWBERRY VALLEY
UTAH
CALIFORNIA
ARIZONA
SALT RIVER
YUMA
7
6
2
3
Supervising engineers districts.
Irrigable areas
Projects under construction.
Projects approved.
SCALE
0 100 200 MILES

MARIAS
MILK RIVER
WILLISTON
LOWER YELLOWSTONE
NORTH DAKOTA
MONTANA
8
HUNTLEY
BELLE FOURCHE
SHOSHONE
SOUTH DAKOTA
WYOMING
9
PATHFINDER RESERVOIR
NORTH PLATTE
NEBRASKA
COLORADO
10
UNCOMPAHGRE
KANSAS
5
GARDEN CITY
OKLAHOMA
4
NEW MEXICO
HONDO
RIO GRANDE
CARLSBAD